ISSN 0377-9335

entomon

A Quarterly Journal of Entomological Research

Vol. 12 SEPTEMBER 1987 No. 3

PUBLISHED BY
THE ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA, KARIAVATTOM
TRIVANDRUM, INDIA 695 581

ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other land arthropods.

Address MS and all editorial correspondence to Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581.

SUBSCRIPTION RATES

Annual Subscription for	institutions:	Rs 150/- (in India);	$ 50/- (abroad, air mail)
,, ,,	individuals:	Rs 50/- ,, ;	$ 20/- (,, sea mail)

1. **All remittance to the journal or the Association should be sent to the Secretary-Treasurer of the Association by bank draft only, A/c payee in favour of the Association for Advancement of Entomology.**

2. **Requests for replacement copies of ENTOMON in lieu of numbers lost in transit, should reach the Secretary-Treasurer not later than three months after the date of publication of the number.**

entomon

Vol. 12 September 1987 Number 3

CONTENTS

Studies on the induction and termination of hibernation of the teak skeletonizer *Eutectona machaeralis* Walker (Lepidoptera : Pyralidae)—**B. V. Patil** and **T. S. Thontadarya** 179

Evaluation of pyrethroid compounds against citrus leaf-miner, *Phyllocnistis citrella* Stainton (Lepidoptera) on 'coorg mandarin'—**B. S. Bhumannavar** 183

Effect of predator-prey density on the prey consumption and daily rate of egg production of the predatory mite, *Amblyseius finlandicus* (Oudemans) (Acarina : Phytoseiidae).—**Neelam K. Sharma** and **G. L. Sadana** 191

Changes in electrical resistance of the cuticle during adult development of *Schistocerca gregaria* Forskal—**P. Arjuna Rao** and **K. N. Mehrotra**... 197

Two new species of *Colobodes* Schonherr (Coleoptera : Curculionidae : Cryptorynchinae) from India—**L. S. Arya, Jasbir Singh** and **H. R. Pajni** 201

A new species of Tanytarsini from India (Diptera : Chironomidae)—**Girish Maheshwari** 207

Effect of diflubenzuron on the egg- and larval-pupal parasites of *Henosepilachna vigintioctopunctata* (Fabricius)—**K. V. Sudhakara Reddy** and **P. Kameswara Rao** 211

Taxonomic studies on the genus *Caryopemon* Jekel (Coleoptera : Bruchidae : Pachymerinae : Caryopemini)—**Shiv K. Singal** 215

Taxonomic studies of genus *Sulcobruchus* Chujo from India (Coleoptera : Bruchidae)—**Shiv K. Singal** 219

An oviposition stimulant in the male accessory gland extract of *Spodoptera litura* (Lepidoptera - Noctuidae)—**R. Sridevi, Aparna Ray** and **P. S. Ramamurty** 231

β-glucuronidase (EC 3.2.1 31) activity during metamorphosis of *Tribolium castaneum* (Hbst) and *T. confusum* (Duval)—**Vilas D. Arabale** 235

Histopathological effect of hexachlorocyclohexane (HCH) on the ovary of adult *Poekilocerus pictus* (Fabr.) (Orthoptera : Acrididae)—**Janak Ahi**... 221

Post-embryonic development of the ovary in the thrips, *Elaphrothrips greeni* (Bagnall) (Thysanoptera : Phlaeothripidae)—**P. S. Watane V. K. Thakare** 247

Acid phosphatase activity in the ovary of the eri silkworm, *Philosamia ricini* (Hutt.) - A histochemical study—**H. K. Hurkadli, M. A. Hooli** and **V. B. Nadkarni**.............. 251

B-chromosome system in a wingless grasshopper, *Orthocris* sp. bol. (Insecta : Acrididae)—**K. Umadeni** and **N. V. Aswathanyrayana**.............. 265

Effects of hydroprene and methoprene on the growth and differentiation of testis of rice stem borer ***Scirpophaga incertulas*** Wlk. (Lepidoptera, Pyralidae) following post-diapause pupal treatments—N. **Roychoudhury** and **S. Chakravorty**.............. 261

Karyological studies iu five species af hormaphidine aphids (Homoptera : Aphididae)—A. **R. Khuda-Bukhsh and Indranil Kar**.............. 267

Karyotypic studies in five species of aphids (Homoptera : Aphididae) from the North-Eastern Himalayas—**A. R. Khuda-Bukhsh** and **G. Basu** 273

Oriental chalcid wasps of the genus ***Trigonura*** Sichel (Hymenoptera : Chalcididae)—**T. C. Narendran**.............. 279

BRIEF COMMUNICATIONS

Ontogenetic study of the haemolymph protein concentration changes in the lemon-Butterfly, *Papilio* ***demoleus*** L.—**V. K. Awasthi, K. P. Srivasava** aad **R. L. Katiyar** 187

Studis on poison baiting for the tobacco caterpillar, *Spodoptera litura* Fb. —**N. Dhandapani, A. Ahdul Kareem and S. Jayaraj**.............. 223

REPORTS AND NEW RECORDS

New record of scale insects (Diaspidae : Homoptera) and an aphelinid parasite (Hymenoptera) from **Kashmir** India—**M. Amin Masoodi** and **A. R. Trali**.............. 227

Eriborus argenteohilosus (Cameron)-A **new** parasite of *Leucinodes orbonalis* Guen—**G. C. Tewari** and **H. R. Sardana**.............. 227

Record of *Aphis craccivora* Koch. and *Aphis gossypii* glov. (Fam : Aphididae) on *Moghania* ***macrophylla*** a host plant of lac insect—**A. K. Sen, A. Bhattacharya** and **S. C. Srivasta**.............. 229

Author Index

Ahi, J., 221
Arabale, V. D., 235
Arya, L. S., 201
Aswathanarayana, N. V., 265
Awasthi, V. K., 187
Basu, G., 273
Bhattacharya, A., 229
Bhumannavar, B. S., 183
Chakravorty, S., 261
Dhandapani, N., 223
Hooli, M. A., 251
Hurkadli, H. K., 251
Jayaraj, S., 223
Kar, I., 267
Kareem, A. A., 223
Katiyar, R. L,, 187
Khuda-Bukhsh, A. R., 268, 273
Maheswari, G., 207
Masoodi, M. A., 227
Mehrotra, K. N., 197
Nadkarni, V. B., 251
Narendran, T. C., 273
Pajni, H. R., 201
Patil, B. V., 179
Ramamurty, P. S., 231
Rao, P. A., 197
Rao, P. K., 211
Roy, A., 231
Reddy, K. V. S., 211
Roychoudhury, N., 261
Sadana, G. L., 191
Sardana, H. R., 227
Sen, A. K., 229
Sharma, N. K., 191
Singal, S. K., 215, 219
Singh, J., 201
Sridevi, R., 231
Srivastava, K. P., 187
Srivastava, S. C., 229
Tewari, G. C., 227
Thakare, V. K., 247
Thontadarya, T. S., 179
Trali, A. R., 227
Umadevi, K., 265
Watane, P. S., 247

Entomon, 1987, *Vol.* **12**, *No.* 3, *pp:* 179 *to* 182

STUDIES ON THE INDUCTION AND TERMINATION OF HIBERNATION OF THE TEAK SKELETONIZER *EUTECTONA MACHAERALIS* WALKER (LEPIDOPTERA : PYRALIDAE)[1]

B. V. PATIL[2] & T. S. THONTADARYA[3]

(Received 6 February 1986)

Laboratory studies on hibernation of the teak skeletonizer, *Eutectona machaeralis* Walker indicated that fully mature larvae ready to form prepupae, when exposed to low temperatures (15° and 20°C) and especially under low relative humidities (35 and 55 per cent) undergo hibernation. Similarly, the termination of hibernation occurred when hibernating larvae were exposed to high temperatures (30° and 35°C) and especially with high relative humidities (75 and 95 per cent)

(Key words: hibernation, induction, termination, teak skeletonizer, *Eutectona machaeralis)*

INTRODUCTION

Teak leaf skeletonizer, *Eutectona machaeralis* Walker (Syn: *Hapalia machaeralis* Walker) and (Syn: *Pyrausta machaeralis* Walker) is one of the serious insect pests of teak *Tectona grandis* L. f. and is known to affect adversely the growth increment in teak (BEESON, 1928). There are normally five larval instars (BEESON, 1941). The total larval period varied depending upon the climatic conditions. It occupied 8 to 12 days in summer and 20 or more days in winter in central and Southern India and there was no hibernation in the larval stage. But at Dehra Dun, the larvae hibernated for a period of 140 to 150 days between November and March (BEESON, 1928, 1941; MATHUR, 1960). During the present investigation, the insect pest, *E. machaeralis* was seen to undergo facultative hibernation (PATIL, 1981) between November and March. Hence, the present study was undertaken to investigate the factors responsible for induction and termination of hibernation. In the past, no such attempts were made on this insect species.

MATERIALS AND METHODS

Induction of hibernation

The study was conducted to find out which stage of the insect is sensitive for the possible induction of hibernation by using different combinations of temperature and relative humidity. The temperatures 15°, 20°, 25°, 30° and 35°C (± 0.05°C) and the relative humidites 35, 55, 75 and 95 per cent (± 3 per cent) were selected for the present investigation. The constant temperatures were maintained in temperature controlled incubators and the required relative humidity levels were obtained by the use of appropriate saturated salt solutions kept in desiccators as suggested by WINSTON & BATES (1960). The different stages of the insect that were exposed to these combinations are presented below:

X_1 = exposure ot eggs till hatching; X_2 = exposure of first and second instar larvae only; X_3 = exposure of 3rd to middle of 5th instar larvae only; X_4 = exposure of larvae ready to form prepupa; X_5 = exposure of one day old prepupa.

---

[1]Part of the Ph.D., thesis of the Senior Author submitted to the U A S, Bangalore.

[2]Agricultural Research Station, Dharwad 580008.

[3]Department of Entomology, College of Agriculture, Bangalore 560 024.

In the remaining period, the insect was reared under laboratory condition (average maximum temperature of 24.7°C and minimum temperature of 18.9°C) where there was no record of hibernation induction during that period. The experiment was replicated five times with five insects in each replication. Observations regading the date of prepupation, pupation and the number of days taken to complete the prepual stage were recorded.

Termination of hibernation

The different combinations of temperature and relative humidity used for induction of hibernation were also used for studying their influence on the termination of hibernation. Field collected hibernating larvae (during November) were exposed. The experiment consisted of 20 treatments and was replicated five times and five insects in each replication. The experiment was discontinued after 94 days of exposure.

The recorded data on the number of days taken for termination of hibernation have been transformed to square root x + 1 and analysed statistically according to split plot design.

TABLE 1. Effect of exposure of different stages of *Eutectona machaeralis* to different combinations of temperature and relative humidity on the duration of prepupal period.

Temperature (°C)	R H (%)	Prepupal period (in days)*				
		X_1	X_2	X_3	X_4	X_5
35	35	2.0	2.0	2.0	1.0	1.0
	55	2.0	2.0	2.0	1.0	1.0
	75	2.0	2.0	2.0	1.0	1.0
	95	2.0	2.0	1.8	1.0	1·0
30	35	2.0	2.0	2.0	1.0	1.0
	55	2.0	2.0	2.0	1.0	1.0
	75	2.0	2.0	2.0	1.4	1.0
	95	2.0	2.0	2.0	1.8	1.0
25	35	2.0	2.0	2.0	2.8	1.0
	55	2.0	2.0	2.2	2.8	1.2
	75	2.0	2.0	2.0	3.0	1.0
	95	2.0	2.0	2.6	3.4	1.4
20	35	2.0	2.0	3.8	0.0/ (94.0)**	7.2
	55	2.0	2.0	5.6	0.0/ (94.0)	8.8
	75	2.0	2.0	5.8	10.0/ (94.0)	10.4
	95	2.0	2.0	6.4	9.0/ (94.0)	11.0
15	35	2.0	2.0	4.0	0.0/ (94.0)	13.2
	55	2.0	2.2	12.8	0.0/ (94.0)	18.0
	75	2.0	2.2	10.0	7.5/ (94.0)	18.8
	95	2.0	2.4	13.6	13.0/ (94.0)	22.2

*Average of five replications. **Numerator indicates the average of non hibernating larvae and denominator indicates the average of hibernating larvae.

( ) Experiment was discontinued after 94 days of exposure. X_1 — Exposure of eggs till hatching. X_2 — exposure of first and second instar larvae only. X_3 — exposure of third to middle of fifth instar larvae only. X_4 — exposure of larvae ready to form prepupa. X_5 — exposure of one day old prepupa.

RESULTS AND DISCUSSION

The results of the effect of different combinations of temperature and relative humidity on the different stages of the insect are presented in Table 1. The normal development period recorded in prepupal stage during January and February was two days. The prolongation of the period due to exposure to different combinations of temperature and relative humidity was an indication for the possible induction of hibernation.

The exposure of stage X_1 (eggs until hatching) to all 20 combinations of temperature and relative humidity did not induce the hibernation in its prepupal period. Similarly, the exposure of stage X_2 (which includes first and second instar larvae only) revealed no induction or the prolongation of its prepupal period. In general, there was no deviation from the normal prepupal period in all the five stages of the insect when exposed to 25°, 30° and 35°C with four levels of relative humidity (35, 55, 75 and 95 per cent) in each. The increase of prepupal period recorded in stages X_3 and X_4 in 25°, 30° and 35°C was negligible. The prepupal period varied from 3.8 to 6.4 days when the stage X_3 (which included third to middle of fifth instar

TABLE 2. Effect (days) of different combinations of temperature and relative humidity on the termination of hibernation in *Eutectona machaeralis* Wlk.

Temperature	different relative humidity levels (in per cent)				
	35	55	75	95	Mean
35°C	4.00* (2.23)**	3.60 (2.14)	3.20 (2.04)	2.80 (1.95)	3.40 (2.09)
30°C	14.20 (3.90)	12.80 (3.70)	8.20 (3.03)	4.60 (2.36)	9.95 (3.25)
25°C	73.60 (8.61)	66.00 (8.06)	25 40 (5.13)	7.60 (2.92)	43.15 (6.18)
20°C	94 00 (9.75)	69.20 (8.27)	22.80 (4.86)	14.40 (3.92)	50.10 (6.70)
15°C	94.00 (9.75)	94.00 (9.75)	94.00 (9.75)	68.80 (8.21)	87.70 (9.36)
Mean	55.96 (6.84)	49.12 (6.38)	30.72 (4.96)	19.64 (3.87)	

*Days taken for pupation after exposing the hibernating larvae. **Figures in parenthesis indicate square root $X + 1$ transformed values used for statistical analysis.

	SED	CD at 5 per cent level
1. Comparison for two temperatures	0.17	0.38
2. Comparison for two relative humidity levels	0.19	0.38
3. Comparing two relative humidity levels at a fixed temperature	0.42	0.85
4. Comparing two temperatures at a fixed level of relative humidity.	0.41	0.83

larva) was exposed to different relative humidities at 20°C. Similarly, it varied from 4.0 to 13.60 days at 15°C under all the four relative humidities. The prolongation was purely temporary and could not be regarded as induction of hibernation. The interesting results were recorded at low temperatures of 15°C and 20°C irrespective of relative humidities. The stage X_4 (which included fully mature larvae ready to form prepupa), when exposed to 15°C and 20°C under all the four relative humidities indicated the onset of hibernation in majority of the prepupae. The prepupae did not pupate upto 94 days after exposure to above combinations of temperature and relative humidity when the experiment was discontinued. Under similar conditions, a few larvae of stage X_4 pupated immediately (7.5 to 13.0 days range) after exposing. This was observed at higher relative humidities both at 15° and 20°C temperatures, but none pupated at 35 and 55 per cent relative humidities at both temperatures. Average days taken to pupate is presented separately (Table 1) which clearly indicates the occurrene of facultative hibernation in this insect. Lastly, the stage X_5 (which included one day old prepupae), when exposed to 15° and 20°C at all the four relative humidities in each, indicated the prolongation of prepupal period to the extent ranging from 7.2 to 22.2 days.

The maximum prepupal period was recorded in the case of stage X_4 when it was exposed to temperatures 15° and 20°C and particularly under low relative humidities of 35 and 55 per cent.

Termination of hibernation

Statistical analysis clearly revealed that all the selected temperatures showed significant difference among one another on the termination of hibernation during the prepupal stage of the insect (Table 2). The longest period of 87.70 days was taken for termination in 15°C, whereas the shortest period of 3.40 days was noted at 35°C. In all the relative humidities (95, 75, 55 and 35 per cent) hibernation terminated in 19.64, 30.72, 49.12 and 55.96 days respectively and varied significantly among each other.

In general, the quickest termination of hibernation noticed was 2.80 days after exposing to the highest temperature (35°C) with the highest relative humidity (95 per cent) and this was found non-significant with 4.60 days at 30°C with 95 per cent relative humidity level.

Acknowledgement: The senior author is thankful to the UNDP/ICAR/UAS for awarding a senior research fellowship during the period of sudy.

REFERENCES

Beeson, C. F. C. (1928) The defoliation of teak. *Indian For.*, **54**, 205—215.

Beeson, C. F. C. (1941) *The Ecology and Control of the Forest Insects of India and the Neighbouring Countries.* Vasant Press, Dehra Dun, p. 1007.

Mathur, R. N. (1960) Pests of teak and their control. *Indian For. Res. N. S. (Ent),* **10**, 44—66.

Patil, B. V. (1981) Bionomics, life tables and biocontrol of the teak skeletonizer, *Pyrausta machaeralis* Walker (Lepidoptera : Pyralidae). Ph. D., Thesis, submitted to UAS., Bangalore, p. 277.

Winston, P. W. & D. H. Bates (1960) Saturated solutions for the control of humidity in biological research. *Ecology*, **41**, 232—236

Entomon, 1987, *Vol.* **12**, *No.* 3, *pp.* 183 *to* 185

EVALUATION OF PYRETHROID COMPOUNDS AGAINST CITRUS LEAF MINER, *PHYLLOCNISTIS CITRELLA* STAINTON (LEPIDOPTERA) ON 'COORG MANDARIN'

B. S. BHUMANNAVAR

Division of Entomology, Central Horticultural Experiment Station, Chethalli, Kodagu, Karnataka, India 571 248

(Received 3 April 1986)

The synthetic pyrethroids fenvalerate, permethrin, decamethrin and cypermethrin at 0.001% concentration effectively controlled citrus leaf-miner and were superior to monocrotophos and quinalphos each at 0.05% concentration.

(Key words: citrus leaf-miner, synthetic pyrethroids, 'Coorg mandarin', control)

INTRODUCTION

The citrus leaf-miner, *Phyllocnistis citrella* Stainton is considered to be a serious pest of citrus and several workers tried different insecticides to control it (BORLE & KHOSDASKAR, 1977; SINGH & RAO, 1977; BATRA & SANDHU, 1981; SHEWALE *et al.*, 1983; SINGH, 1984). Though there are effective insecticides to suppress the population, reinfestation of leaf miner occurs within a week after application. The leaf-miner problems are season bound in rainfed orchards and manyfold in irrigated orchards. Newer insecticides such as pyrethroid compounds are being tested against citrus leaf miner (VIVEKANANDAN & NAGANATHAN, 1983; NAGALINGAM & SAVITHRI, 1983; ITO *et al.*, 1982; MO *et al.*, 1981). In the present investigations some more synthetic pyrethroids at three lower concentrations have been evaluated against citrus leaf-miner.

Contribution No. 32/86 of Indian Institute of Horticultural Research, 255, Upper Palace Orchards, Sadashivanagar, Post Box No. 8025, Bangalore 860 080.

MATERIALS AND METHODS

A field experiment was conducted in November 1984 on five year old 'Coorg mandarin' citrus plants at Central Horticultural Experiment Station, Chethalli in a randomized block design. Each treatment was replicated four times, assigning single tree per treatment. Six insecticides were included in this trial along with a control (Table 1). The pyrethroids were applied in three concentrations i. e., 0.01%, 0.005%, 0.001%. Spraying was done once and each tree was sprayed with 0.75 litres of spray fluid and the control plants were sprayed with water. Before spraying, ten leaf-miner infested flushes were tagged on each tree and the total number of larvae were recorded. Insecticides were applied in early morning hours of the day to avoid drift. After 1, 3, 7, 10, 15 and 20 days of spraying, counts were taken of dead larvae and at each count larvae entering into pupal stage were collected and kept under laboratory observation for adult emergence/confirmation of death.

In addition to the tagged flushes, the new emerging flush was observed for the fresh incidence of leaf-miner which confirmed the residual toxicity of the insecticide in offering the protection to trees. After working out the per cent mortality the data was subjected to statistical analysis and the results are presented here.

TABLE 1. Efficacy of synthetic pyrethroids against citrus leaf-miner, *Phyllocnistis citrella* Stainton on 'Coorg mandarin'.

Name of the insecticide	concentration %	percentage mortality of leaf miner after* (in days)					insecticide per hectare)	
		1	3	7	10	20	qnantity[1] ha	cost/ha Rs. Ps.
Monocrotophos (Nuvacron 40 EC)	0.05	90.00 (74.14)	97.50 (85.39)	100.00 (90.00)	**	**	625ml	125.00
Quinalphos (Ekalux 25 EC)	0.05	91.94 (78.36)	97.22 (85.13)	100.00 (90.00)	**	**	1000ml	120.00
Permethrin (Ambush 50 EC)	0.01	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	**	100ml	52.00
-do-	0.005	86.38 (71.33)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	**	50ml	26.00
-do-	0.001	89.44 (76.33)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	**	10ml	5.20
Fenvalerate (Fenvel 20 EC)	0.01	82.30 (68.25)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	250ml	105.00
-do-	0.005	97.50 (85.39)	97.50 (85.39)	100,90 (90.00)	100.90 (90.00)	**	125ml	52.50
-do-	0.001	90.00 (74.14)	97.50 (85.39)	100.00 (90.00)	100.00 (90.00)	**	25ml	10.50
Decamethrin (Decis 2.8 EC)	0.01	86.87 (68.96)	95.00 (80.78)	100.00 (90.00)	100.00 (90.00)	**	50ml	23.75
-do-	0.005	79.16 (63.69)	97.50 (85.39)	100.00 (90.00)	100.00 (90 00)	**	25ml	11.87
-do-	0.001	85.00 (70.45)	97.50 (85.39)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	5ml	2.37
Cypermethrin (Ripcord 10 EC)	0.01	92.50 (78.75)	97.50 (85.39)	100.00 (90.00)	100.00 (90.00)	**	500ml	205.00
-do-	0.005	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.90)	250ml	102.50
-do-	0.001	90.00 (77.09)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	**	50ml	20.50
Control (water spray	—	24.44 (25.89)	53.45 (46.97)	77.29 (65.08)	78.71 (66.21)	**		
CD (p = 0.05)		(15.191)	(9.227)	(5.685)	(5.324)			

Weather condition during the experimental period : Max. Temp. 30.1°C; Min. Temp. 21.8°C Relative humidity: Range : 36.5% to 84.2%; Rainfall : Nil. *Average of 4 replications.
**Reinfestation started. Figures in parenthesis are transformeds values.
1@ 500 litre spray mixture / hectare.

RESULTS AND DISCUSSION

The results of the experiment are presented in Table 1. It was found that the synthetic pyrethroids were effective even when they were applied in a concentration which is ten times lower than the recommended concentration. Permethrin (0.01%) and cypermethrin (0.005%) registered cent per cent larval mortality 24 hours after spray. The above two pyrethroids and fenvalerate (0.005%) were significantly superior to other treatments, 24 hours after application. All the insecticidal treatments were significantly superior over control (water spray). Permethrin (0.01%, 0.005%, 0.001%), fenvalerate (0.01%) and cypermethrin (0.005%, 0.001%) recorded cent per cent larval mortality on third day after application and were on par with other treatments. Monocrotophos (0.05%) and quinalphos (0.05%) could register only 97.5% and 97.22% larval mortality on this day. Complete larval mortality was recorded by all the insecticides at all concentrations on seventh day after application. Reinfestation of leaf-miner was noticed in monocrotophos (0.05%) and quinalphos (0.05%) on tenth day after spray whereas in pyrethroids only after 20 days.

The findings of ITO *et al.* (1982); MO *et al.* (1981); VIVEKANANDAN & NAGANATHAN (1983) and NAGALINGAM & SAVITHRI (1983) agree with the results of present investigation.

Acknowledgements: The author is grateful to Dr. K. L. CHADHA, Director, Indian Institute of Horticultural Research, Bangalore for providing facilities and to Mr. K. B. KARIAPPA and Miss M. K. PADMAVATHY for their technical assistance in conducting the experiment.

REFERENCES

BATRA, R. C. & G. S. SANDHU (1981) Differential population of citrus leaf-miner and its parasites on some commercial citrus cultivars. *J. Res. Punjab agric. Univ.*, **18**(2), 170—176.

BORLE, M. N. & P. S. KHOSDASKAR (1977) Pesticidal trials against citrus leaf-miner, lemon butterfly and citrus mite in Vidarbha region. *Int. Symp. Citriculture*, Bangalore P. 35.

ITO, T., T. SHIBATA, K. SHIMOHARA & K. KAWACHI (1982) Characteristics of fenvalerate in controlling the citrus leaf-miner *Phyllocnistis citrella* Stainton (Lepidoptera Gracilariidae). *Entomology and Zoology*, **17** (2), 284—286.

MO, Y. S., P. T. LU & S. R. HUANG (1981) A good result in control of citrus leaf-miner with pyrethroids. *Guangdong nongye keuene* No. 6, 47—48.

NAGALINGAM, B. & P. SAVITHRI (1983) Studies on the chemical control of citrus leaf-miner *Phyllocnistis citrella* Stainton(Gracillariidae:Lepidoptera). *Pestology*, **4**(7), 21—24.

SHEWALE, B. S., P. V. MAKAR & V. U. KHAROLE (1983) Insecticidal control of citrus leaf-miner (*Phyllocnistis citrella*). *Pestology*, **5** (1), 9—10.

SINGH, B. D. (1984) Studies on the bionomics and control of citrus leaf miner *Phyllocnistis citrella* Stainton. *Pesticides* **18**(12), 46—50.

SINGH, S. P. & N. S. RAO (1977) Chemical control of citrus leaf-miner, *Phyllocnistis citrella* Stainton with various systemic insecticides. *Int. Symp. Citriculture*, Bangalore P. 33—34.

VIVEKANANDAN, P. & T. G. NAGANATHAN (1983) Efficacy of insecticides in the control of citrus leaf-miner, *Pesticides*, **17** (9),22—23.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 187 *to* 189

BRIEF COMMUNICATION

ONTOGENETIC STUDY OF THE HAEMOLYMPH PROTEIN CONCENTRATION CHANGES IN THE LEMON-BUTTERFLY, *PAPILIO DEMOLEUS* L.

V. K. Awasthi, K. P. Srivastava & R. L. Katiyar

Department of Zoology, Banaras Hindu University, Varanasi, India 221 705

(Received 3 April 1986)

Colorimetric estimation of the haemolymph protein concentration (HPC) in *Papilio demoleus* shows small levels of it in the I-IV larval instars and pupa and high levels in the V instar and adult. Sexes in the V instar, pupa and adult show essentially similar patterns of HPC though its peaks in the V instar larva and adult are significantly higher in the female than in the male.

(Key words: haemolymph protein concentration, ontogeny, *Papilio demoleus)*

A survey of literature reveals that there have been more studies on HPC in the larva, few in the pupa and fewer still in the adult but none to our knowledge in all three stages within a single lepidopterous species. It was therefore thought desirable to carry out this study in all three stages of the lemon-butterfly, *Papilio demoleus* to get a comprehensive and a more meaningful picture of the HPC changes.

The I–IV instar larvae were examined in late stages of their development, the V (ultimate) instar, pupa and adult on 1 day intervals for 6 days in the first two stages that correspond to the duration of these instars and 4 days in the last stage during which mating and egg laying take place. Sexes were taken into account from V instar onwards. The HPC was determined on a systronic spectro 103 colorimeter by the method of Lowry *et al.* (1951).

The HPC in the I instar larva starts at a low level, rises a little in the II and III instars, takes a small dip in the IV instar, rising steeply in the V instar up to day 5 and declining thereafter (Table 1). Starting at a higher level than that in the ultimate instar larva, the HPC in the pupa rises a little in its mid-stage and declines thereafter until the imaginal moult. In the adult, the HPC shoots up during the first 2 days in the male and the first 3 days in the female, declining thereafter. The patterns of HPC changes in the sexes of the V instar onwards are essentially similar though in the male of the V instar and adult, the peaks are significantly lower ($P < 0.0001$) than those in the female.

The HPC changes in *Papilio demoleus* are essentially similar to those reported for other holometabolous insects (Gilbert & Schneiderman, 1961; Chen & Levenbook, 1966; Wyatt & Pan, 1978; Chen, 1985). However, comments on the significance of these changes in other species are limited to the stages investigated rather than comprehensively to the postembryonic development as a whole. Haemolymph proteins have been assigned functions that play a

TABLE 1. HPC during the postembryonic development in *P. demoleus*.

Stage	age	HPC (mg / ml ± SE)*		
		larvae (I-IV instars)	larva V puua and adult	
			male	female
Larva (instars)				
I	late stage	4.05 ± 0.67		
II	,,	4.95 ± 0.78		
III	,,	8.59 ± 0.73		
IV	,,	6.08 ± 0.58		
V	day 0		6.31 ± 0.71	7.73 ± 0.32
	,, 1		7.35 ± 0.68	7.12 ± 0.40
	,, 2		9.79 ± 1.00	12.87 ± 0.61
	,, 3		24.56 ± 0.68	32.07 ± 0.65
	,, 4		26.33 ± 0.70	42.37 ± 0.75
	,, 5		28.92 ± 0.81	43.17 ± 1.05
	Pre pupa		25.45 ± 0.31	36.25 ± 0.60
Pupa				
	day 0		19.85 ± 0.74	14.77 ± 0.56
	,, 1		16.91 ± 1.05	18.55 ± 0.61
	,, 2		18.14 ± 0.87	20.40 ± 0.54
	,, 3		19.36 ± 0.80	18.10 ± 0.64
	,, 4		15.81 ± 0.65	16.83 ± 1.03
	,, 5		12.35 ± 0.63	13.68 ± 0.64
	,, 6		10.39 ± 0.71	11.88 ± 0.46
Adult				
	,, 1		35.24 ± 0.55	36.45 ± 0.48
	,, 2		42.21 ± 0.43	49.14 ± 0.39
	,, 3		38.07 ± 0.56	54.56 ± 0.63
	,, 4		34.52 ± 0.87	41.21 ± 1.25

*Each datum is an average of 5 insects.

dominant role in the growth and metamorphosis of insects (CHEN & LEVENBOOK, 1966; CHEN, 1985; LEVENBOOK, 1985). In *Drosophila*, the increase in total protein content during the development parallels closely that in both wet and dry weight (= growth) of the insect (CHURCH & ROBERTSON, 1966). The low level of HPC in the early (I–IV) instar larvae, therefore, seems commensurate with the low degree of growth and development in these instars. The V (ultimate) instar larva, on the other hand, shows maximum growth and so a high level of HPC. The factors leading to this condition could be an accumulation of storage proteins known to increase enormously, especically in the last larval instar (LEVENBOOK, 1985), and the voracious feeding habit of the instar that would tend to enhance the dietary source of proteins. However, a low level of HPC in the pupa seems intriguing because being the metamorphic stage, it should require larger amounts of proteins for the construction of adult structures. The phenomenon could be explained by the facts known in other insects namely, some proteins may

enter pupal fat body for storage (Tojo *et al.*, 1980) and some may be transported to the pupal cuticle (Koeppe & Gilbert, 1973). Besides, the capacity of the fat body to synthesise proteins also falls after it changes to a storage organ (see Tojo *et al.*, 1980). In the adult, there is a steep rise in the HPC once again in both the sexes. Since oviposition occurs 2—3 days after adult emergence a rise in the HPC during this period may be related to the maturation of oocyte. The occurrence of large amounts vitellogenic proteins in the haemolymph at this time is already a well known in most insects (Hagadorn & Kunkel, 1979). A rise of HPC in the male points to the possibility of the testes also needing haemolymph proteins for their own maturation. This presumption, however, will need verification.

Acknowledgement: The authors are thankful to the CSIR for financial support.

REFERENCES

Chen, P. S. (1985) Amino acid and proteins metabolism, 177—217, *in: Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vol. **10**, (eds. Kerkut, G. A. & L. I. Gilbert) Pergamon Press.

Chen, P. S. & L. Levenbook (1966) Studies on the haemolymph proteins of the blowfly, *Phormia regina*. I. Changes in ontogenetic pattern. *J. Insect Physiol.*, **12**, 1595—1605.

Church, R. B. & F. W. Robertosos (1966) Biochemical analylis of the growth of *Drosophila melanogaster*. *J. exp. Zool.*, **162**, 337—352.

Gilbrt, L. I. & H. A. Schneiderman (1961) Some biochemical aspects of insect metamorphosis. *Amer. Zool.*, **1**, 11—51.

Hagadorn, H. H. & J. G. Kunkel (1979) Vitellogenin and vitellin in insects. *A. Rev. Ent.*, **24**, 475—505.

Koeppe, J. K. & L. I. Gilbert (1973) Immunochemical evidence for the transport of haemolymph proteins into the cuticle of *Manduca. sexta. Biol. Rev.*, **19**, 615—624.

Levenbook, L. (1985) Insect storage proteins, 307-346, *in: Comprehensive Insect Physiology*, Biochemistry and Pharmacology, Vol. **10**, (eds. Kerkut, G. A. & L. I. Gilbert) Pergamon Press.

Lowry, O. H., M. J. Rosenbrough, A. L. Farr & R. J. Randall (1951) Protein measurements with the Folin Phenol reagent. *J. biol. Chem.*, **193**, 264—275.

Tojo, S., M. Nogata & M. Kobayashi (1980) Storage proteins in the silkworm, *Bombyx mori*. *Insect Biochem*, **10**, 289—303.

Wyatt, G. R. & M. L. Pan (1978) Insect plasma proteins. *A. Rev. Biochem.*, **47**, 778—817.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 191 *to* 195

EFFECT OF PREDATOR-PREY DENSITY ON THE PREY CONSUMPTION AND DAILY RATE OF EGG PRODUCTION OF THE PREDATORY MITE, *AMBLYSEIUS FINLANDICUS* (OUDEMANS) (ACARINA : PHYTOSEIIDAE).

NEELAM K. SHARMA & G. L. SADANA
Department of Zoology, Punjab University, Chandigarh, India

(Received 3 June 1985)

The predator and prey densities affected the predation rate and daily rate of egg production of the predatory mite, *Amblyseius finlandicus*. In general, the number of prey consumed increased with the increase in prey density at predator-prey ratios of 1:10 to 1:30 but then decreased with increase in predator density. The predation rate increased with the increase in predator density from 1 to 2 or 3 at higher prey densities (50—100). The daily rate of egg production increased with increase in prey density at predator-prey ratios of 1:10 and 1:30 but with increase in predator density, the daily rate of egg production decreased with single predator but with increase in predator density from 1 to 2 or 3 it first increased and then decreased. The multiple predators reduced the population of prey quickly.

(Key words: Mite, predator-prey interaction)

INTRODUCTION

Eutetranychus orientalis (Klein) is a serious pest of citrus in Punjab having a wide host range (SADANA, 1982). *Amblyseius finlandicus* has been reported to feed voraciously on this phytophagous mite (GUPTA *et al.*, 1971) and it has been observed that *A. finlandicus* has many remarkable features in its life history e. g. it has short developmental period shorter than its prey mite, *E. orientalis*, cent per cent viability of eggs, very low mortality, very short preoviposition period with longer oviposition period, good extent of feeding and a wide feeding range (KUMARI, 1984). It has also been observed that prey density affects the rate of prey consumption and daily rate of egg production (SHARMA *et al.*, 1985). The density of predators is also an important factor influencing the dynamics of predator prey system because it may affect individual attack rate through increased prey exploitation or interference. Keeping this in mind, the experiments were conducted to study the effect of varying predator-prey densities on number of prey consumed and daily rate of egg production per predator. The results obtained are presented here.

MATERIALS AND METHODS

To study the effect of prey and predator density on prey consumption and daily rate of egg production, the predatory mites of 3 days old which had laid at least two eggs were confined to leaf discs of citrus (3 cm^2) placed on moist cotton in petridishes under laboratory conditions at temperatures averaging minimum 27.6°C and maximum 30.5°C. The predator densities used initially ranged from 1 to 5 at prey densities 10 to 20 but as this number was found to be less, the density of

predators and prey was increased and it ranged from 1 to 10 and 30 to 100 for predators and prey, respectively. The experiment was replicated five times. Eggs laid by the females were removed daily and observations were recorded for ten days. The dead and shrivelled individuals were considered as consumed by predator. The experimental data were subjected to one way classification analysis of variance (ANOVA) and the means were compared after calculating critical difference (C D at 0.5% significant level as per formula:

$$C\,D = \text{tdf (Error sum of squares)} \sqrt{\frac{2\,E\,M\,S}{n}}$$

where : tdf = value of t at degree of freedom of error and sum of squares; EMS = mean of sum of squares of errors; n = number of replicates.

RESULTS AND DISCUSSION

It is evident from the data that the mean number of prey consumed per predator declined at prey densities 10, 20, 30 and 40 with increase in predator density but increased with increase in predator density from 1 to 2 or 3 at higher prey densities (50-100) and then showed a declining trend with increase in predator density (Table 1). In majority of the cases the number of prey were insufficient at high predator densities. It is evident from the data that multiple predators were consistently more efficient in reducing the number of prey than single predator. Similar results were reported by Eveleigh & Chant (1982a) in *Amblyseus degenerans*. It was observed that number of prey consumed increased with increase in prey density above predator density 3. At predator densities 1, 2 and 3, the number of prey consumed first increased with increase in prey density but after reaching a plateau, started decreasing (Table 1) i. e., the functional response of *A. finlandicus* was of Holling's type II (Holling, 1961) at predator densities 1, 2 and 3 but changed to type I with increase in predator densities. Eveleigh & Chant (1982a) reported that the functional response curves for *A. degenerans* became more linear as predator density increased but those of *Phytoseiulus persimulis* did not become more linear with increasing predator density.

The number of prey consumed per predator per day was found to be significant at 0.5% level of significance at all levels of predator densities except between predator densities 7 and 8, 8 and 9, and 9 and 10 at prey density 80, between 9 and 10 at prey density 100 and at all predator densities except at 1 at prey density 30.

It was observed that the mean rate of daily egg production per predator decreased with increase in predator density at prey densities 10, 20 and 30 (Table 2) but at higher prey densities, first it increased with increase in predator density (1 to 2 or 3) and afterwards decreased with further increase in predator density. Kuchlein (1966) also found that the fecundity in *Typhlodromus longipilis* decreased with increase in predator density. Eveleigh & Chant (1982b) reported that mean fecundity per day per predator in *P. persimulis* decreased when the predator density was increased from 1 to 2, 4 and 6 at prey densities of 40, 60 and 120 but that of *A. degenerans* decreased with increase in predator density at prey densities of 40 and 120 but increased with increase in predator density from 1 to 2 at prey density of 60 and then decreased with further increase in predator density. It appears that with increase in prey and predator densities the disturbance to the predatory mite increases and as a result fecundity decreases.

The difference between the daily rate of egg production per predator was found

TABLE 1. Mean number of prey consumed (mean ± S D) per day per predator (*A. finlandicus*) after feeding upon *F. orientalis* at various prey and predator densities.

Prey density	predator density 1	2	3	4	5	6	7	8	9	10	P^*	critical difference (C D)
10	10.00 ± 0.00	5.00 ± 0.00	3.33 ± 0.00	2.50 ± 0.00	2.00 ± 0.00	—	—	—	—	—	<.005	0
20	20.00 ± 0.00	10.00 ± 0.00	6.66 ± 0.00	5.00 ± 0.00	4.00 ± 0.00	—	—	—	—	—	<.005	0
30	23.82 ± 0.970	15.00 ± 0.00	10.00 ± 0.00	7.50 ± 0.01	6.00 ± 0.00	5.00 ± 0.00	4.28 ± 0.00	3.75 ± 0.00	3.33 ± 0.00	3.00 ± 0.00	<.005	6.5460
40	22.50 ± 0.166	19.98 ± 0.800	13.33 ± 0.600	10.00 ±0.00	8.00 ± 0.00	6.66 ± 0.00	5.71 ± 0.00	5.00 ± 0.00	4.44 ± 0.00	4.00 ± 0.00	<.005	0.7194
50	21.50 ± 0.296	22.21 ± 0.290	16.66 ± 0.00	12.50 ± 0.00	10.00 ± 0.00	8.33 ± 0.00	7.14 ± 0.00	6.25 ± 0.00	5.55 ± 0.00	5.00 ± 0.00	<.005	0.2213
60	20.82 ± 0.276	24.73 ± 0.140	20.00 ± 0.00	15.00 ± 0.00	12.00 ± 0.00	10.00 ± 0.00	8.57 ± 0.00	7.50 ± 0.00	6.66 ± 0.00	6.00 ± 0.00	<.005	0.1017
70	20.62 ± 0.648	23.86 ± 0.860	22.96 ± 0.130	17.50 ± 0.00	14.00 ± 0.00	11.66 ± 0.00	10.00 ± 0.00	8.75 ± 0.00	7.77 ± 0.00	7.00 ± 0.00	<.005	0.2817
80	20.18 ± 0.620	21.70 ± 0.130	19.76 ± 0.110	17.88 ± 1.26	14.84 ± 0.940	13.33 ± 0.00	11.43 ± 0.00	10.00 ± 0.00	8.88 ± 0.00	8.00 ± 0.00	<.005	1.7970
90	19.30 ± 0.458	20.140 ± 0.380	21.01 ± 0.100	18.74 ± 0.10	15.78 ± 0.210	14.38 ± 0.250	12.54 ± 0.030	11.25 ± 0.00	10.00 ± 0.00	9.00 ± 0.00	<.005	0.8331
100	18.70 ± 0.244	19.36 ± 0.120	22.74 ± 0.073	20.44 ± 0.100	16.24 ± 0.061	14.91 ± 0.048	14.18 ± 0.048	11.89 ± 0.088	11.11 ± 0.088	10.00 ± 0.00	<.005	0.6124

P^* Probabilities from F values obtained from ANOVA.

TABLE 2. Daily rate of egg production (mean ± S D) per predator (*A. finlandicus*) after feeding upon *E. orientalis* at various prey and predator densities.

Prey density	predator density										P^*	critical difference (C D)
	1	2	3	4	5	6	7	8	9	10		
10	1.74 ±0.480	0.30 ±1.26	0.16 ±0.400	0.025 ±0.630	0.008 ±0.370	—	—	—	—	—	<.005	0.0753
20	2.44 ±0.800	1.24 ±1.72	0.70 ±0.630	0.43 ±0.400	0.13 ±0.480	—	—	—	—	—	<.005	0.1098
30	2.68 ±0.960	2.06 ±1.600	1.74 ±0.480	1.12 ±1.160	0.07 ±1.010	0.47 ±0.890	0.30 ±0.740	0.20 ±1.350	0.11 ±0.080	0.06 ±0.480	<.005	0.0346
40	2.04 ±0.480	2.53 ±1.630	1.73 ±1.460	1.30 ±1.200	0.94 ±0.800	0.72 ±1.01	0.60 ±1.700	0.46 ±0.174	0.28 ±0.60	0.16 ±0.740	<.005	0.3052
50	1.22 ±0.600	2.95 ±0.210	2.25 ±0.630	1.47 ±0.800	1.15 ±0.450	0.94 ±0.540	0.74 ±0.200	0.55 ±0.140	0.46 ±0.350	0.39 ±0.260	<.005	0.1520
60	1.18 ±0.090	2.70 ±0.140	2.60 ±0.380	1.99 ±0.140	1.59 ±0.100	1.21 ±0.060	0.93 ±0.240	0.68 ±0.600	0.59 ±0.250	0.49 ±0.130	<.005	0.2197
70	1.12 ±0.180	2.76 ±0.920	3.18 ±0.670	2.51 ±0.330	1.91 ±0.380	1.57 ±0.300	1.29 ±0.010	0.98 ±0.280	0.81 ±0150	0.66 ±0.010	<.005	0.1174
80	1.08 ±0.180	1.39 ±0.800	1.66 ±0.200	1.69 ±0.200	1.60 ±0.050	1.58 ±0.200	1.53 ±0.170	1.30 ±0.300	0.93 ±0100	0.68 ±0.13	<.005	0.2877
90	0.92 ±0.520	0.93 ±0.080	1.75 ±0.040	1.56 ±0.050	1.47 ±0.160	1.46 ±0.030	1.31 ±0.100	1.22 ±0.090	1.02 ±0.020	0.73 ±0.03	<.005	0.1762
100	0.78 ±0.074	0.82 ±0.070	1.14 ±0.180	1.77 ±0.180	1.80 ±0.010	1.91 ±0.600	1.89 ±0.652	1.88 ±.0089	1.86 ±0.040	1.46 ±0.120	<.005	0.1462

P^* Probabilities from F values obtained from ANOVA.

to be statistically significant at 0.5% level at all predator and prey densities of 10, 20, 30 and 70 whereas at other predator prey densities it was found to be nonsignificant at 0.5% level between predator densities of 6 and 7, 7 and 8, 8 and 9 and 9 and 10 at prey density 40, between 8 and 9, 9 and 10 at 50 and between 2 and 3, 3 and 4, 5 and 6 and 9 and 10 at prey density of 100.

The studies on the effect of predator and prey density on predation and daily rate of egg production show that the density of predator in a confined area can have an important effect on the rate of population increase of *A. finlandicus*. As the predator density increases, the number of prey available to each predator decreases and eventually a point is reached when the prey are insufficient for the predator to meet their requirements for egg laying and all the prey are consumed in a confined space (leaf disc). However, in natural environment where there are fewer restrictions on the movement of predators, they may migrate from these areas before this level of prey exploitation is reached.

Acknowledgements: The authors are thankful to Dr. S. S. Guraya, Head, Deptment of Zoology, Punjab Agricultural University, Ludhiana for providing necessary laboratory facilities. The senior author is also grateful to Council of Scientific and Industrial Research (CSIR) for the award of Senior Research Fellowship.

REFERENCES

Eveleigh, E. S. & D. A. Chant (1982a) Experimental studies on acarine predator-prey interactions: the effects of predator density on prey consumption, predator searching efficiency and the functional response to prey density (Acarina : Phytoseiidae). *Can. J. Zool.* **60**(4), 611—629.

Eveleigh, E. S. & D. A. Chant (1982b) Experimental studies on acarine predator-prey interactions : the effects of predator density on immature survival, adult fecundity and emigration rates, and the numerical response to prey density (Acarina : Phytoseiidae) *Can. J. Zool.* **60** (4), 630—638.

Gupta, S K., M. S. Dhooria & A. S. Sidhu (1971) A note on predators of citrus mite in Punjab *Sci. & Cult.*, **37**(10), 484.

Holling, C. S. (1961) Principles of insect predation. *A. Rev. Ent.*, **6**, 163—182.

Kuchlein, J H. (1966) Mutual interference among the predacious mite *Typhlodromus longipilus* Nesbitt (Acari, Phytoseiidae). I. Effects of predator density on oviposition rate and migration tendency. *Medad. Rjksfac. Landbourwwet. Gent.*, **31**, 740—746.

Kumari, N. (1984) Biology and ecology of predatory mite, *Amblyseius finlandicus* and its evaluation as biological control agent. Ph.D. thesis, Punjab Agricultural University.

Sadana, G. L. (1982) Final report of ICAR scheme entitled 'Taxonomic studies on plant feeding mites of India' (Tetranychoidea) 1978—1982).

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 197 *to* 199

CHANGES IN ELECTRICAL RESISTANCE OF THE CUTICLE DURING ADULT DEVELOPMENT OF *SCHISTOCERCA GREGARIA* FORSKAL

P. ARJUNA RAO[1] & K. N. MEHROTRA

Division of Entomology, Indian Agricultural Research Institute, New Delhi, India 110 012

(Received 21 February 1986)

The study repotrs the change is electrical resistance (AC) of the cuticle of adult *Schistocerca gregaria* Forskal from immediately after moulting to 15 days after moulting. The average specific resistance (RS) of the cuticle, across the pronotum, increased trom 7.30 K Ω -cm^2 for freshly moulted adults to 24.59 K Ω -cm^2 for males and 25.38 K Ω cm^2 for females at 15 days after moulting. The resistance across forewings changed from 8.42 K Ω -cm^2 for freshly emerged males and from 8.44 K Ω –cm^2 for freshly emerged females to 45.10 K Ω -cm^2 at 15 days after moulting. The increase in the cuticle resistance was very high during the first 24 h after moulting and was negligible between 10th to 15th day.

(Key words: AC Resistance, moulting, cuticle, pronotum, forewings)

INTRODUCTION

The physical properties of insect cuticle, such as permeability to water and ions, the mechanical penetrability, rigidity and the chitin and protein deposition and their interactions, change from time after moult (RICHARDS, 1951; WIGGLESWORTH, 1972; NEVILLE, 1975). The chitin-protein interactions resulting in the stabilization of cuticle after moulting, depends on the amount of chitin, which is synthesized for sometime after moulting (NEVILLE, 1975). The permeability of cuticle, also changes gradually for some time after moulting. The gradual sclerotization and hardening leads to the changes in other physical properties of cuticle. The water and ionic permeability of cuticle also changes after moulting and it is closely related to the electrical resistance (SCHEIE & SMYTH, 1968) of the cuticle.

SCHEIE & SMYTH (1967, 1968) reported that there was a large increase in resistance of the cuticle of adult *Periplaneta* from the time after moult. The cuticle resistance changed from $12 \pm 16 \times 10^3$ Ω—cm^2 for freshly moulted cuticle to $50 + 15 \times 10^3$ Ω—cm^2 for cuticle excised 2 weeks after moult. It was suggested that the change in cuticle resistance after moulting occurred due to the physiological changes associated with the cuticle after moulting.

MATERIALS AND METHODS

The desert locust was reared in the laboratory according to MEHROTRA & RAO (1966). After final moult the adults were restrained on a soft plastic sponge in a plastic case. Two drops of 0.1 M NaCl (electrolyte-solution) were placed on the integument at a small distance from one another. Two electrodes fixed to a

[1]Present address: Department of Entomoiogy, College of Agriculture, A. P. Agricultural University, Rajendranagar, Hyderabad 500 030.

movable stand and connected to C R O, were lowered to make contact with the electrolyte drops. The electrical resistance between the two electrodes was calculated with the help of Ohm's law. The current was adjusted with the help of a potentiometer and the potential difference developed across a 4.7 M Ω resistor was fed to the imput terminals to the horizontal amplifier of the C R O. A 'V' (voltage) 'I' (current) curve was obtained on the oscilloscope screen and the corresponding 'V' and 'I' measurements were recorded. The adult locusts after final moulting were measured at different ages for their electrical resistance of the cuticle. The specific resistance (Rs) was calculated with the formula $Rs = \frac{V}{I} \times \frac{A}{2}$, where, 'V' is the voltage; 'I' is the current and 'A' is the area of one of the electrolyte drop. The Rs is expressed in K Ω -cm².

RESULTS

The average Rs (Table 1) of the cuticle of adult males across pronotum was 7.30 ± 0.64 immediately after moulting. It increased to 17.6 ± 1.61 during the first day and to 19.67 ± 1.71 during the second day after moulting. The Rs continued to increase to 22.69 ± 1.66 by 6th day and 24.59 ± 1.93 by 15 day after moulting. The pattern of increase in the cuticle resistance from time of moulting reveals that there is a steep increase during the first day, the increase was 5.06 from 1st day to 6th day and 1.90 from 6th day to 15th day after moulting. In adult females the average Rs was 7.35 ± 0.62 immediately after moulting. It increased to 17.88 ± 1.67 during first day, 19.69 ± 1.77 by 2nd day, 23.02 ± 1.77 by 6th day and 25.38 ± 1.88 by 15th day after moulting. The increase in Rs after moulting in adult females was similar to that of males. Besides the steep increase during the first day after moulting, the increase in cuticle resistance was more from 1st to 6th day than from 6th day to 15 day after moulting.

TABLE 1. Average Rs across pronotum and forewings of adult *S gregaria* from time after moult (K cm²).

Age in days	pronotum male	pronotum female	forewings male	forewings female
0	7.30 (0.64)	7.35 (0.62)	8.42 (0.69)	8.44 (0.65)
1	17.63 (1.61)	17.88 (1.67)	30.91 (2.14)	30.61 (2.20)
2	19.67 (1.71)	19.69 (1.77)	35.95 (2.34)	33.87 (2.17)
3	20.60 (1.74)	20.94 (1.88)	36.85 (2.58)	35.46 (1.74)
4	21.42 (1.84)	21.86 (2.07)	38.17 (2.36)	37.46 (2.32)
5	22.19 (1.70)	22.44 (1.98)	39.39 (2.28)	39.18 (2.58)
6	22.69 (1.66)	23.02 (1.77)	40.60 (2.38)	40.49 (2.27)
7	23.14 (1.56)	23.59 (1.83)	41.59 (2.53)	41.41 (2.73)
8	23.62 (1.67)	22.25 (2.05)	42.40 (2.73)	42.53 (2.65)
9	24.02 (1.81)	24.69 (1.95)	43.23 (2.87)	43.35 (2.49)
10	24.18 (2.01)	24.91 (1.98)	43.93 (2.97)	43.76 (3.66)
15	24.59 (1.95)	25.38 (1.88)	45.10 (2.59)	45.10 (3.10)

Each datum is an average of 16 observations. Figures in parenthesis are the standard deviations.

The average Rs across the forewings of the adult male was 8.42 ± 0 64 immediately after moulting. It was 30.91 ± 2.14 on 1st day, 40.60 ± 2.38 on 6th day and 45.10 ± 2.59 on 15th day after moulting. In adult females it was 8.44 ± 0.65 immediately after moulting, 30.61 ± 2.20 on 1st day, 40.49 ± 2.29 on 6th day and 45.10 ± 3.10 on 15 day after moulting. It is also seen from these results that both in adult male and female locusts the electrical resistance of the cuticle

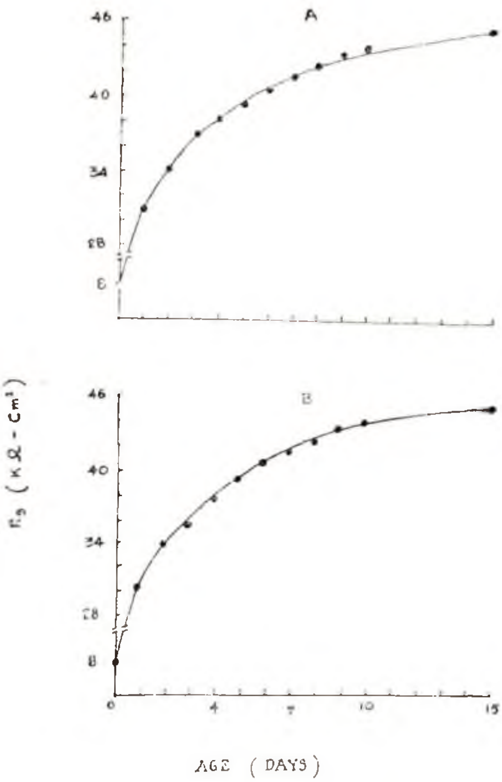


Fig. 1. Changes in electrical resistance on the wings of adult *Schistocerca gregaria* from time after moult.

increased tremendously during first day: from 8.42 to 30.92 in males and from 8.44 to 30.61 in females. The increase in cuticle resistance was 9.69 and 9.88 in males and females respectively from 1st day to 6th day after moulting, while it was only 4.19 and 4.49 from 6th day to 15th day.

Another interesting point is, the increase in cuticle resistance from 10 day to 15th day was very little whether it is adult male or female or across pronotum or forewings.

DISCUSSION

The results on electrical resistance of cuticle from the time after moulting suggest that the resistance of the cuticle was at its minimum immediately after moulting. It gradually increases and gets stabilized around 8–10 days after moulting. The resistance just after moulting was around 7 K Ω—cm^2 on pronotum and 8 K Ω—cm^2 on forewings. The resistance on pronotum was same as observed by SCHEIE & SMYTH (1968) on pronotum of *P. americana* just after moulting. It is also interesting to note that the resistance on pronotum of *P. americana* was found to increase continuously even after 20 days after moulting (SCHEIE & SMYTH, 1968) while in *S. gregaria* it gets stabilized around 8–10 days after moulting. However, the pattern of increase in cuticle resistance was similar to that observed by SCHEIE & SMYTH, (1967,1968) for the first 10 days, with very steep increase during the first few hours after moulting. These facts also lead to the suggestion that besides having direct relation with the ion permeability of the cuticle, the resistance of the cuticle also changes during various phases of formation of new cuticle after moulting and hardening process.

REFERENCES

MEHROTRA, K. N. & P. J. RAO (1966) Phagostimulants for locusts. *Indian J. exp. Biol.*; 4, 46—57.

NEVILLE, A. C. (1975) *Biology of the Arthropod Cuticle*. Springer, Berlin, 488 pp.

RICHARDS, A. G. (1951) *The Integument of Arthropods*. Minnesotta. 411 pp.

SCHEIE, P. O. & T. SMYTH (Jr.) (1967) Electrical measurement on cuticle excised from adult male *Periplaneta americana* (L.) *Comp. Biochem. Physiol.*, **21**, 547—571.

SCHEIE, P. O. & T. SMYTH (Jr.) (1968) The electrical resistance of intact integument of *Periplaneta americana* (L.). *Comp. Biochem. Physiol.*, **26**, 399—414.

WIGGLESWORTH, V. B. (1972) *The Principles of Insect Physiology*. Chapman and Hall Limited Lnndon, 827 pp.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 201 *to* 206

TWO NEW SPECIES OF GENUS *COLOBODES* SCHONHERR (COLEOPTERA : CURCULIONIDAE : CRYPTORYNCHINAE) FROM INDIA

L. S. ARYA[1], JAGBIR SINGH & H. R. PAJNI

Department of Zoology, Punjab University, Chandigarh, India 160 014

(Received 6 February 1986)

Colobodes spinisquamosus and *C. tetramaculata* two new species are described and illustrated. A key to Indian species of *Colobodes* is given.

(Key words: new species, *Colobodes*, Curculionidae)

The genus *Colobodes* Schonherr is so far known from India by two species, viz., *Colobodes dolichotis* Marshall, 1936 and *C. acalloides* (Desbrochers des Loges, 1891) out of which *C. dolichotis* Marshall is a pest of *Dolichos lablab* in South India while the other is economically insignificant and reported to be collected from wild vegetation and unknown wood of the North-Eastern Himalayas. However, the material for the present studies was either collected under a US PL-480 project on Curculionidae during 1975-1981 or borrowed on loan from the Entomological Museum of Forest Research Institute, Dehradun (UP). The identification was confirmed by comparing the material with co-types of the species namely, *Colobodes dolichotis* and *C. acalloides* which are available in British Museum (NH), London.

Colobodes spinisquamosus sp. nov. (Figs. 1—3)

Derm sparsely clothed with scales, dorsum bearing several small tubercles. Pronotum with six tufts of erect scales arranged in two horizontal rows.

Head piceous, small, coarsely punctate, densely clothed with recumbent dirty greyish-yellow scales concealing derm entirely; eyes lateral, creamy-white, ovate. *Rostrum* piceous, subcylindrical, stout, almost as broad at base as frons, as long as prothorax, acarinate, completely punctate, densely clothed with recumbent greyish-black scales at base, glabrous in remaining area. *Antennae* reddish-brown, inserted at middle of rostrum; scape rather long, as long as first six funicular segments combined; funicle not pubescent, with segment 1 longer as well as broader than other segments, 3—5 longer than broad, 6 and 7 transverse; club densely pubescent, fusiform, compact, acuminate at tip. *Pronotum* piceous, broader than long, parallel-sided in basal half thereafter narrowed towards apex, without subapical constriction, truncate at base, longitudinally convex, coarsely punctate, densely clothed with recumbent oblong greyish-yellow scales, besides, few scattered erect oblong black scales and 6 tufts of erect yellow scales of which

[1]Present address: Biologist, Incharge, Urban Malaria Seheme, Thanesar, Kurukshetra 132 118 (Haryana).

Fig. 1. Adult of *Colobcdes spinisquamosus*, sp nov.

two at apical and 4 in middle arranged in transverse row with median having exceptionally long scales.

Scutellum elongate, much longer than broad, black, shiny, bare.

Elytra piceous, much broader at base than pronotum, parallelsided in basal half gradually narrowed towards apex, with well developed, roundly rectangular, backwardly projecting shoulders and moderately developed subapical calli, longitudinally convex, bulging in middle and sloping towards both ends; striae rather fine, concealed by scales of intervals; intervals flat except for same protuberances at intervals, 2, 3 and 5 bearing tufts of erect greyish-yellow scales, densely clothed with recumbent smokygrey scales and tufts of erect scales at intervals 2, 3, 5 and 7 just behind base and near declivity.

Legs with femora subclavate, densely clothed with smoky-grey recumbent scales interspersed with a few scattered, erect, pale setae; tibia curved at base, gradully broadening from middle to apex, densely clothed with fumate scales, mixed with a few scattered setae; tarsal segment 1 longer than 2 and 3 combined; claws free and simple.

Sternal canal reaching just behind hind end of mid-coxae. *Abdominal* sternites distantly punctate, each puncture furnished with a scale or seta.

Male genitalia (Fig. 2) with aedeagus widest at base thereafter tapering towards apex, posteriorly arcuate, more sclerotized at sides; aedeagal apodemes two times as long as aedeagus, inwardly curved for a distance at base thereafter quite straight, uniformly sclerotized; endophallus densely hairy for a distance at apex; phallotreme subapical, large, roughly rectangular; phallobasic ring complete, uniformly sclerotized; phallobasic apodeme rather broad but short; parameres absent. *Gastral spiculum* (Fig. 3) with median arm slightly curved, pointed at apex, uniformly sclerotized.

Measusements: Body length: 4.62 mm; Body width: 2.52 mm; Rostrum length: 1.26 mm; Rostrum width: 0.35 mm. Specimen examined: One.

Holotype: Male; WEST BENGAL: Kalimpong, Samsing 1800'; A. M. Posford Coll.; 21. v. 1934.

Type-Depository: Entomological Museum, Forest Research Institute, Dehradun (U P), India.

Remarks: This species is entirely different from the other Indian species

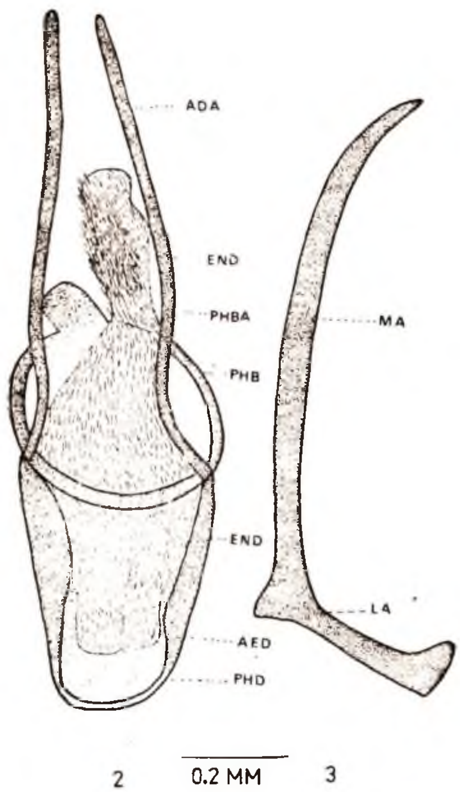


Fig. 2. Male genitalia of *C. spinisquamosus*, sp. nov. (Dorsal view).
Fig. 3. Gastral spiculum of *C. spinisquamosus*, sp. nov.
For Abbreviations used, see page 204.

in having very rough vestiture on the pronotum and elytra. The spine-like long scales are arranged in tufts and stand out prominently on the entire surface.

Colobodes tetramaculata, sp. nov. (Figs. 4—8).

Rather small species bearing deep and wide furrow along dorsal margins of eyes. Pronotum elevated in middle. Elytra with intervals several time broader than striae and provided with tubercles at intervals 3 and 5.

Head fulvous, coarsely and reticulately punctate, sparsely furnished with recumbent pale to brown scales, with deep and wide furrow along dorsal margin of each eye, beset with a few oblong erect scales along inner margins of eyes; eyes glistening white, lateral, oval, rounded above and acuminate below. *Rostrum* ferrugineous, glabrous, almost as broad at base as frons, cylindical, uniformly broad all along its length, slightly curved downward behind antennal insertion, closely punctate in basal half in male whereas in basal third in female, though finely punctate in remaining part, with a few erect scales at sides and those behind finely setose. Antennae pale-brown, inserted at about middle of rostrum in female, behind middle in male; funicle sparsely pubescent, with segment 1 as long as 2, 3—7 transverse and 7 longer and broader than others; club densely pubescent, fusiform, with joint 1 longer than 2 and 3 combined.

Pronotum ferrugineous, slightly broader than long, parallelsided in basal half, thereafter narrowed towards apex, with feeble subapical constriction, feebly bisinuate at base, longitudinally convex, strongly elevated in middle, coarsely and rugulosely punctate, with most of punctures beset with recumbent brown scales concealing them while a few provided with erect, oblong black or light-brown scales either irregularly scattered as in basal half and apical area or forming four tufts of scales in raised areas of dorsum arranged in a horizontal row. *Scutellum* small, rounded, convex, shiny, bare.

Elytra ferrugineous, broader at base than pronotum, subcordate, parallel-sided in basal third thereafter roundly narrowed towards apex, widest behind middle, with moderately developed apical calli and roundly rectangular shoulders; striae rather narrow, each strial puncture

accommodating a horizontal seta; intervals several times broader than striae, densely clothed with recumbent brown and black scales along with a few erect black scales either scattered unevenly or forming tufts on tubercles of intervals 3 and 5; elytral vestiture brownish-black with two white spots at intervals 2 and 3 behind middle.

Legs with femora subclavate, clothed with black scales, each with large triangular tooth below in apical region, hind femora only in female with a pale patch in subapical region; tibia curved at base thereafter quite straight, beset with black, recumbent scales externally and with sparse, brown scales internally, with a pale patch at apex: tarsal segment 1 longer than 2 and 3 combined.

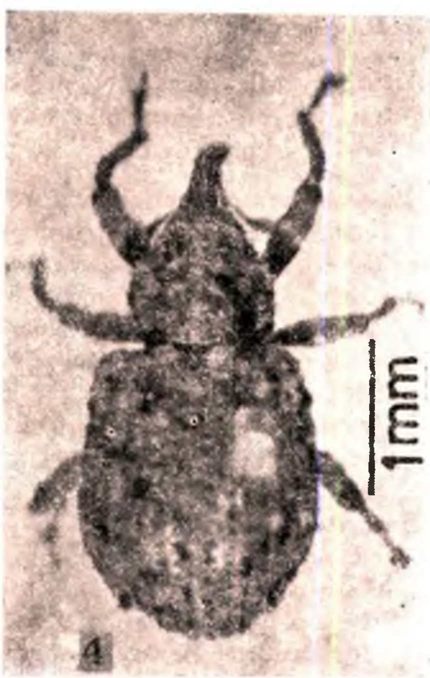


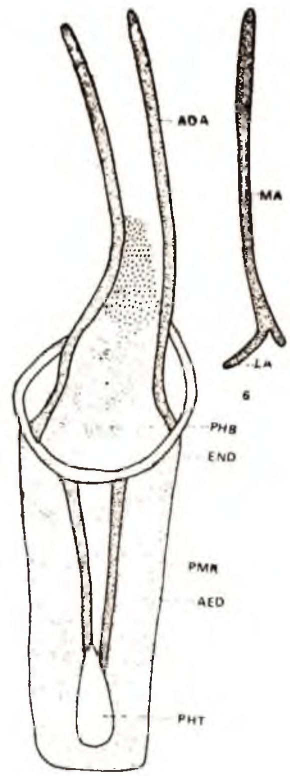
Fig. 4. Adult of *C. tetramaculata*, sp. nov.

Sternal canal reaching middle of mid-coxae. *Metasternum* with median sulcus in apical half, closely punctate and punctures furnished with suberect setae in middle and with recumbent pale scales at sides. *Abdominal sternites* devoid of scales except for a few at sides of sternite 1, sternites 1, 2 and 5 closely punctate whereas 3 and 4 each with a horizontal row of punctures, each puncture beset with fine seta; the incision between sternites rather deep and wide.

Male genitalia (Fig. 5) with aedeagus parallel-sided, posteriorly truncate, weakly sclerotized; aedeagal apodeme slightly longer than aedeagus, weakly sclerotized; endophallus without any sclerite but its wall studded with small granules for some distance at apical end; phallotreme subapical, large, conical; phallobasic ring complete, with phallobasic apodeme half as long as paramere, as sclerotized as phallobase. *Gastral spiculum* (Fig. 6) almost straight, uniformly sclerotized. *Female genitalia* (Fig. 7) with coxites rather long, tubular, widely separated, moderately sclerotized, styli small, slightly longer than broad, more sclerotized than coxites; *spiculum ventrale* uniformly sclerotized, with lateral arms subequal, fused at base, separated at tip. *Spermatheca* (Fig. 8) curved, comma-shaped, with cornu arcuate; collum small, distinct, lobe-like; ramus tubular, parallel with cornu.

ABBREVIATIONS USED

ADA : Aedeagal apodeme; **AED** : Aedeagus; **COL** : Collum; **COR** : Cornu ; **COX** : Coxite; **END** : Endophallus; **ENDP** : Endophallic plate; **GS** : Gastral spiculum; **LA** : Lateral arm; **MA** : Median arm; **PHB** : Phallobase; **PHBA** : Phallobasic apodeme; **PHT** : Phallotreme; **PMR** : Paramere; **RAM** : Ramus, **SE** : Setae; **STY** : Stylus; **SV** : Spiculum ventrale.



02MM

Fig. 5. Male genitalia of *C. tetramaculata*, sp. nov.

Fig. 6. Gastral spiculum of *C. tetramaculata*, sp. nov.

0 2MM

Fig. 7. Female genitalia of *C. tetramaculata*, sp. nov.

Fig. 8. Spermatheca of *C. tetramaculata*, sp. nov.

For Abbreviations used, see page 204.

Measurements: Body length: 3.50 mm 4.20 mm; Body width: 2.10—2.40 mm; Rostrum length: 0.84—1.00 mm; Rostrum width: 0.18—0.25 mm. Specimens examined: Four.

Holotype : Female; TAMIL NADU: WYNAAD, Kannoth: S. N. Chatterjee Coll.; *Grewia tiliafolia*; 20. x. 1938. **Paratypes:** Two males; data as that of holotype. **Paratype:** Female; middle Andaman; unknown creeper; B. M. Bhatia Coll., 9. xi. 1928.

Type-Depository: Entomological Museum, Forest Research Institute, Dehradun (U P), India.

Remarks: This species is the smallest of Indian species. The pronotum and elytra hrve low tubercles and fewer number of scales as compared to other species. The species is named after the presence of two unequal whitish patches of scales on the intervals 2 and 3 of each elytron. Similar white spots are also present on the elytra of *C. dolichotis* Marshall but

the surface of elytra and pronotum in the latter species is much more densely and roughly covered with dull brownish-pale scales.

KEY TO THE INDIAN SPECIES OF GENUS *COLOBODES* SCHONHERR

1. Funicular segment 1 shorter than 2. Pronotum with longitudinal pale stripe on either side. Scutellum setose......*dolichotis* Marshall
— Funicular segment 1 as long as or longer than 2. Pronotum without pale stripe. Scutellum bare.. 2
2. Funicular segment 1 longer than 2. Pronotum with inner tufts of median row with very long scales. Elytra much broader at base than pronotum..*spinisquamosus*, sp. nov.
— Funicular segment 1 as long as 2. Pronotum with scales of all tufts of median row equally long. Elytra at base only slightly broader than pronotum.............. 3
3. Pronotum with a transverse row of four tubercles in middle. Scutellum elongate. Elytra with shoulders oblique; striae rather narrow..*acalloides* (Desbrochers des Loges)
— Pronotum without tubercles. Scutellum rounded. Elytra with shoulders roundly rectangular; striae comparatively broader. ....*tetramaculata*, sp. nov.

Acknowledgements: The authors are thankful to the authorities of British Museum (N H), Londdon for allowing the comparison of collection with the types, and to Dr. P. K. SEN-SHARMA of Forest Research Institute, Dehradun (U P) for lending some material on loan. The research facilities provided by the Chairman, Department of Zoology, Punjab University, Chandigarh, are also acknowledged.

REFERENCES

DESBROCHERS des LOGES, M. J. (1891) Curculionides at Brenthides du Bengale occidental recuillis par de R. P. Cardoon avec description d' especes nouvelles. *Ann. Soc. Ent. Belg.*, **35**, 250—361.

FAUST, J. (1898) Beschreibung neuer Coleopteren von Vorder–und Hinterindein. *Deutsche ent. Zeitscher.*, **1898**, 314—317.

HUSTACHE, A. (1936) *Coleopterorum catalogus*, **151**, *Curculionidae:Cryptorhynchinae*, 317 pp.

MARSHALL, C. A. K. (1936), Curculionidae (Coleoptera) attacking cultivated plants. *Bull. ent. Res.*, **27**, 256.

SCHONHERR, C. I. (1837) Genera et species curculionidum, 4 (1), 465.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp:* 207 *to* 210

A NEW SPECIES OF TANYTARSINI FROM INDIA (DIPTERA : CHIRONOMIDAE)

GIRISH MAHESHWARI

School of Entomology, St. John's College, Agra, India 282 002

(Received 21 February 1986)

A new species of *Tanytarsus*, *Tanytarsus ipei*, is described here on the basis of the material collected from the Botanic Garden, St. John's College, Agra and reared in the laboratory at 25 ± 2°C.

(Key words: new species, Tanytatsini)

The terms used in this paper are after Mc-Alpine (1981) and Saether (1980) for adult morphology.

Tanytarsus ipei sp. nov.

Adult male : Body length 3.25 mm.

Colour : General body colour brown. Head brown, frontal tubercle light brown. Pedicel dark brown, flagellum brown. Palpi light brown. Thorax dark brown. Legs light brown. Abdomen hairy with dark blakish-brown bands. Male genitalia brown.

Head: Eyes reniform with dorsal extension and bare. Frontal tubercle well doveloped.

Palpi : Palpi five segmented. Palpal proportion 5 : 4 : 9 : 13 : 24.

Antenna : Flagellum with thirteen flagellomeres. Antennal ratio 1.4.

Thorax : Scutum projecting well beyond levei of reduced antepronotum. Acrostichal setae in two rows, dorsocentral and supra-alar setae present. Setae present on scutellum.

Wing: Wing membrane with microtrichia. Macrotrichia present on the veins only. Anterior veins slightly darker than the posterior ones. R_{4+5} ends slightly proximal to M. Cubital fork distal to crossvein r-m. Cu_1 straight, Cu_2 curved. Wing length 1.80mm. Venarum ratio 1.20.

Legs : Apex of foretibia with a scale and a spur. First tarsomere larger than the first tibia. Middle tibia with two spurs and a comb, occupying at most half circumference of tibial apex. Apex of hind tibia with two spurs and a comb. Pulvilli absent. Length of segments (mm) and leg ratio are given below :

	Fe	Ti	Ta_1	Ta_2	Ta_3	Ta_4	Ta_5	L R
Fore leg	0.69	0.40	0.91	0.42	0.36	0.28	0.13	2.28
Mid leg	0.79	0.61	0.37	0.19	0.16	0.12	0.07	0.68
Hind leg	0.84	0.81	0.55	0.33	0.26	0.17	0.12	0.68

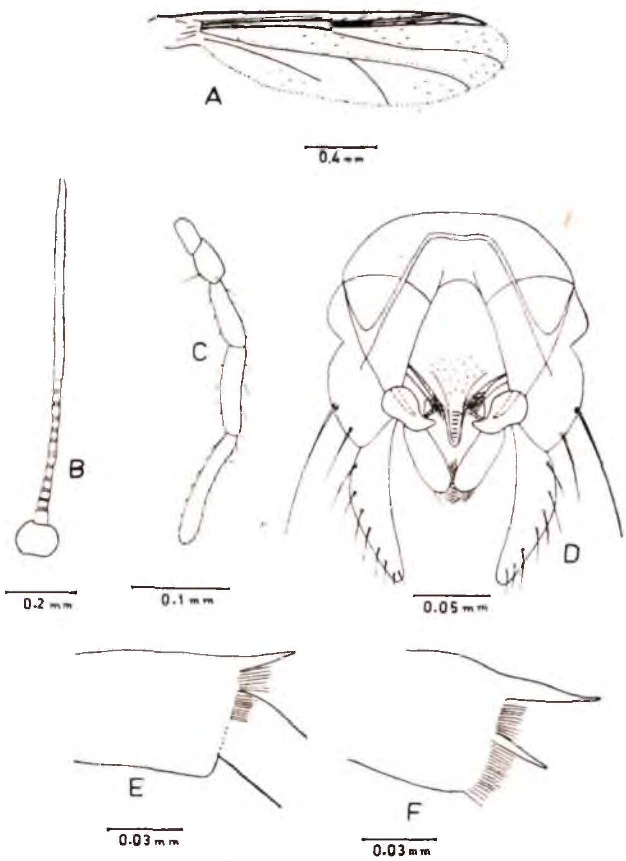


Fig. 1. *Tanytarsus ipei* ♂. A—Wing, B—Antenna, C—Palp, D—Genitalia, E—Apex of middle tibia, F—Apex of hind tibia.

Genitalia : Ratio of gonocoxa and gonostylus 1.47. Apex of anal point rounded. Anal point with seven transverse bands. Aedeagus visible in mounted specimen. Appendage 1 more or less reniform with 2 long hairs on its inner margin. Appendage 1a present. Appendage 2 reaching much beyond the end of gonocoxite and strongly capitate with posteriorly directed bristles. Appendage 2a with a number of bristles at its apex. Ratio of appendage 2 and appendage 1 is 2.18.

Adult female : Body length 2.76mm.

Colour : Same as adult male.

Head : Eyes reniform and bare. Frontal tubercle small.

Palpi : Palpi five segmented. Palpal proportion 6 : 4 : 11 : 12 : 27.

Antenna : Flagellum with four flagellomeres. Length of the apical flagellomere 0.15 mm.

Wing : Wing venation same as in male. Wing length 1.96 mm. venarum ratio 2.21.

Legs : Apex of foretibia with a scale and spur. First tarsomere of foreleg

longer than the first tibia. Two spurs and a comb present on the apex of mid & hind tibia. Length (mm) of segments and leg ratio are as follows :

	Fe	Ti	Ta_1	Ta_2	Ta_3	Ta_4	Ta_5	L R I
Fore leg	0.65	0.40	0.89	0.36	0.19	0.27	0.12	2.25
Mid leg	0.72	0.61	0.36	0.16	0.12	0.09	0.05	0.57
Hind leg	0.77	0.79	0.48	0.25	0.24	0.13	0.08	0.61

Genitalia : Sternite VIII has 2 ovoid spermatheca. Tergite VIII with a number of setae. Hypoproct plate well marked. Cercus rounded and with a number of setae.

Diagnosis : *Tanytarsus ipei* resembles *Tanytarsus ungulituberculata* Singh and Kulshrestha (1975) but differs in the structure of male genitalia and in venarum ratio. *Tanytarsus ipei* was compared

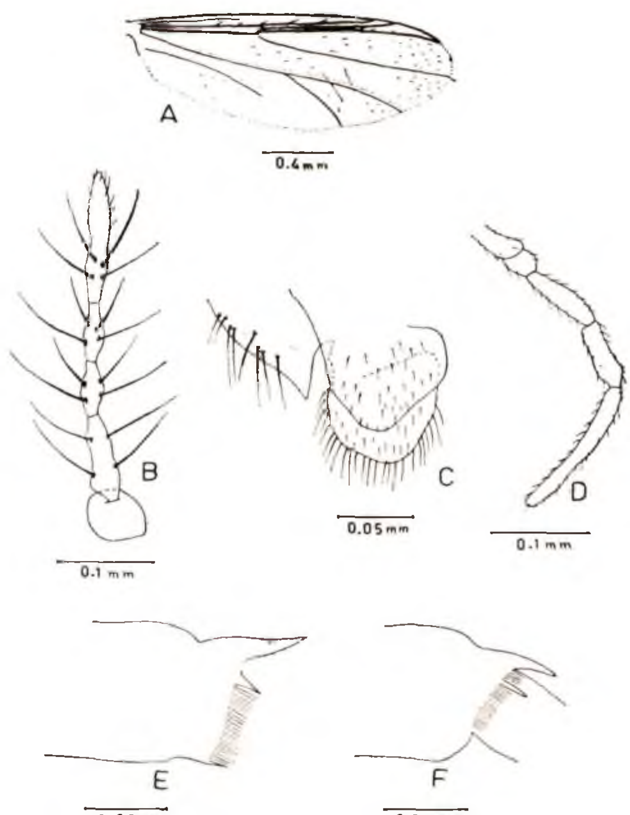


Fig. 2. *Tanytarsus ipei* ♀. A—Wing, B—Antenna, C—Genitalia, D—Palp, E—Apex of middle tibia, F—Apex of hind tibia.

with the holotype of *Tanytarsus ungulituberculata* which is available in the School of Eotomology, St. John's College, Agra.

The differences in taxonomic characters of *T. ipei* and *T. ungulituberculata* are given below:

T. ungulituberculata	*T. ipei*
1. Male body length 2.50 mm.	Male body length 3.25 mm.
2. Palpi four segmented.	Palpi fiive segmented.
3. Antennal ratio 1.45.	Antennal ratio 1.40.
4. Venarum ratio less than one.	Venarum ratio more than one.
5. Leg ratio 2.47.	Leg ratio 2.24.
6. Anal point punctate. Punctate nine, arranged in a single row.	Anal point with seven transverse bands.
7. Appendage 1, with three long hairs on inner margin.	Appendage 1, with two long hairs on inner margin.

Material : Holotype ♂. INDIA : Botanic Garden, St. John's College, Agra. 7.i.1986 (♂ and ♀ emerged. Girish Maheshwari. In Coll. School of Entomology, St. John's College, Agra, India.

Paratype : ♂ ♂ and ♀ ♀ on slides and on pin, same data as holotype.

REFERENCES

McALPINE, J. F. (1981) Morphology and terminology adults. pp 9–63, *in Manual of Nearctic Diptera.* Vol. 1. *Agric. Can. Monog.*, **27**, 674 pp.

SAETHER, O. A. (1977) Female genitalia in Chironomidae and other Nematocera : Morphology, Phylogeney, Keys. *Bull. Fish Res. Bd Can.*, **197**, 209 pp.

SAETHER, O. A. (1980) Glossary of Chironomid Morphology, Terminology (Diptera:Chironomidae). *Ent. Scand Suppl.*, **14**, 51 pp.

SINGH, SANTOKH & A. K. KULSHRESTHA (1975) Three new species of *Tanytarsus* (Diptera : Chironomidae). *Oriental Ins.*, **9**(4), 410–424.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 211 *to* 213

EFFECT OF DIFLUBENZURON ON THE EGG- AND LARVAL-PUPAL PARASITES OF *HENOSEPILACHNA VIGINTIOCTOPUNCTATA* (FABRICIUS)

K. V. Sudhakara Reddy & P. Kameswara Rao

Department of Entomology, S. V. Agricultural College, Tirupati, India 517 502

(Received 6 February 1986)

The effect of diflubenzuron on the egg and larval-pupal parasites due to contact toxicity on the egg and larval stages of *Henosepilachna vigintioctopunctata* (Coccinellidae : Coleoptera) was studied. The per cent emergence of parasite *Tetrastichus ovulorum* (Ferriere) from the treated parasitised eggs ranged from 97.00 to 100.00 while the mean number of *Pediobius foveolatus* (Crawford) emerged from treated parasitised larvae and pupae were 89.7 and 62.6 as against 88.0 and 65.0 in control respectively indicating no adverse effect of diflubenzuron due to contact action on the parasite emergence.

(Key words: Henosepilachna vigintioctopunctata, Tetrastichus ovulorum, Pediobius foveolatus, diflubenzuron)

INTRODUCTION

Diflubenzuron exercises the insecticidal activity mainly as a stomach posion. However, contact toxicity also has been reported on the egg and larval stages of certain pests. Ovicidal action of diflubenzuron was observed in case of castor semilooper and tobacco caterpillar by Rao & Reddy (1984). Contact larvicidal action was reported by Balasubramanian *et al.* (1980) and by Ananthakrishnaswamy & Punnaiah (1983) in case of *Spodoptera littoralis* (Boisd). Punnaiah *et al.* (1984) observed 100 per cent mortality of the fourth instar larvae of garden hairy caterpillar with diflubenzuron as contact poison. When such is the case internally developing egg- and larval parasites are likely to be affected when host is exposed to diflubenzuron. The effect of diflubenzuron on the egg- and larval-pupal parasites of *H. vigintioctopunctata*, a serious endemic pest of brinjal, was therefore studied.

MATERIALS AND METHODS

The healthy egg clusters of *H. vigintioctopunctata* were exposed to the egg parasite, *Tetrastichus ovulorum* (Ferriere) in glass tubes for parasitisation under laboratory conditions. Similarly the healthy grubs and pupae were subjected to larval-pupal parasite, *Pediobius foveolatus* (Crawford) for parasitsiation under laboratory conditions. The one day old parasitised eggs, grubs and pupae were sprayed separately with diflubenzuron at nine concentrations (Table 1) under Potter's tower at 25 lb/sq. inch. One egg mass, five grubs and five pupae each were maintained under each treatment with three replications. Observations were made on the mean number and per cent parasite emergence.

RESULTS AND DISCUSSION

Diflubenzuron showed no effect on the emergence of adult parasites from the treated parasitised eggs, grubs and pupae (Table 1). The mean per cent emergence of egg parasite, *T. ovulorum* ranged from 96.72 to 100.00 as against 98.91 in the control. The treated parasitised eggs turned black and emerged 8 to 10 days after parasitisation. Mean number of

TABLE 1. Effect of diflubenzuron on the emergence of the parasites of immature stage of *H. vigintioctopunctata*.

Concentration %	mean parasite emergence		
	T. ovulorum[1] from eggs (%)	*P. foveolatus*[2] from larvae (No.)	from pupae (No.)
0.1	98.94 (83.98)	84.67 (9.20)	65.00 (8.06)
0.075	98.28 (82.51)	85.33 (9.24)	65.00 (8.06)
0.05	97.59 (81.09)	90.67 (9.52)	57.33 (7.57)
0.025	99.45 (85.95)	90.67 (9.52)	60.00 (7.75)
0.0125	99.11 (84.56)	94.00 (9.70)	62.33 (7.89)
0.01	99.32 (85.20)	90.33 (9.50)	60.33 (7.78)
0.0075	98.48 (82.97)	89.00 (9.43)	60.67 (7.79)
0.005	96.72 (79.53)	89.67 (9.47)	66.67 (8.17)
0.0025	100.00 (90.00)	94.67 (9.73)	63.67 (7.98)
Control	98.91 (83.98)	88.00 (9.30)	65.00 (8.06)
Mean	98.68	89.7	62.60
F test	N S	N S	N S

[1]Figures in the parenthesis are angular transformed values.
[2]Figures in the parenthesis are square root transformed values.

adult parasites of *P. foveolatus*, emerged from five parasitised grubs and pupae from each ranged from 84.67 to 94.67 and 57.33 to 66.67 as against 88.00 and 65.00 in the control respectively. The emergence of parasites in the control was statistically at par with different treatments suggesting that the contact action of diflubenzuron had no adverse effect on the internally developing egg- and larval-pupal parasites of *H. vigintiocto-punctata*. On dissection of the treated parasitised host grubs, many parasitic yellowish grubs were observed in healthy condition in the haemocoel. This was in support of MATHEWS (1981) who reported that diflubenzuron was relatively safe to adult predators and parasites.

Acknowledgement: The authors are thankful to Dr. Z. BOUCEK, Commonwealth Institute of Entomology, London for his kind identifiatication of the parasites. Thanks are also due to R. L.N. MURTHY of Duphar, B. V., Madras for supplying the chemical, Dimilin (R) 25 W P and to Dr. (Smt.) K. C. CHITRA, Associate Professor in Entomology for her keen interest in the present studies. The help rendered by K. SUBRAHMANYAM REDDY, Assistant Professor in Statistics in the statistical analysis of the data is duly acknowledged.

REFERENCES

ANANTAKRISHNA SWAMY S. P. & K. C. PUNNAIAH (1983) Effect of diflubenzuron against

tobacco caterpillar, *Spodoptera litura*. *Andhra agric. J.*, 30 (3), 19_—195.

BALASUBRAMANIAN, M., R. NATESAN & K. MOHANVEL (1980) Diflubenzuron, a chitin synthsis inhibitor on *Spodoptera litura* and *Heliothis armigera*. *Andhra agric. J.*, **27** (1&2), 74–79.

MATHEWS, G. A. (1984) *Pest management*. Longman Inc., New York, pp. 76.

PUNNAIAH, K. C., V. RAMASUBBA RAO, K. RAMASUBBAIAH & V. V. L. MAYURVALLI (1984) Effect of diflubenzuron on the larvae and pupe of garden hairy caterpillar *Pericallia ricini*. *Andhra agric. J.*, **31** (2), 163.

RAO, G. D. J. P. & G. P. V. REDDY (1984) The effect of diflubenzuron against castor semilooper and tobacco caterpillar. *Andhra agric. J.*, **31**(3), 196—200.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 215 *to* 218

TAXONOMIC STUDIES ON THE GENUS *CARYOPEMON* JEKEL (COLEOPTERA : BRUCHIDAE : PACHYMERINAE : CARYOPEMINI)

SHIV K. SINGAL

Department of Entomology, Haryana Agricultural University, Hisar (Haryana), India 125 004

(Received 6 February 1986)

Genus *Caryopemon* Jekel and its type-species *C. hieroglyphicus* Jekel are redescribed in detail and illustrated.

(*Keywords :* *Caryopemon,* Bruchidae)

INTRODUCTION

Genus *Caryopemon* was erected by Jekel (1855) for the type species *Caryopemon hieroglyphicus* with 'India Orientalis' its locality. Bridwell (1929) raised the subfamily Pachymerinae and assigned the genus *Caryopemon* and its closely related genus *Diegobrvchus* to the newly raised tribe caryopemini and differentiated it from other two tribes of subfamily Pachymerinae. The second tribe Caryedini is represented by genus *Caryedon* in India whereas the third tribe Pachymerini remains unrepresented.

Bridwell (1929) had examined a series of specimens of *C. hieroglyphicus* from Mormugao (Goa), Bandra, (Bombay) and Madras. A complete description of *C. hieroglyphicus* and structure of its male genitalia is presented here.

Genus *Caryopemon* Jekel

1855 *Caryopemon* Jekel, Insecta Saunders 1 : 25.

1896 *Caryopemon* Jekel : Lacord, Gen. Col. 7 : 606.

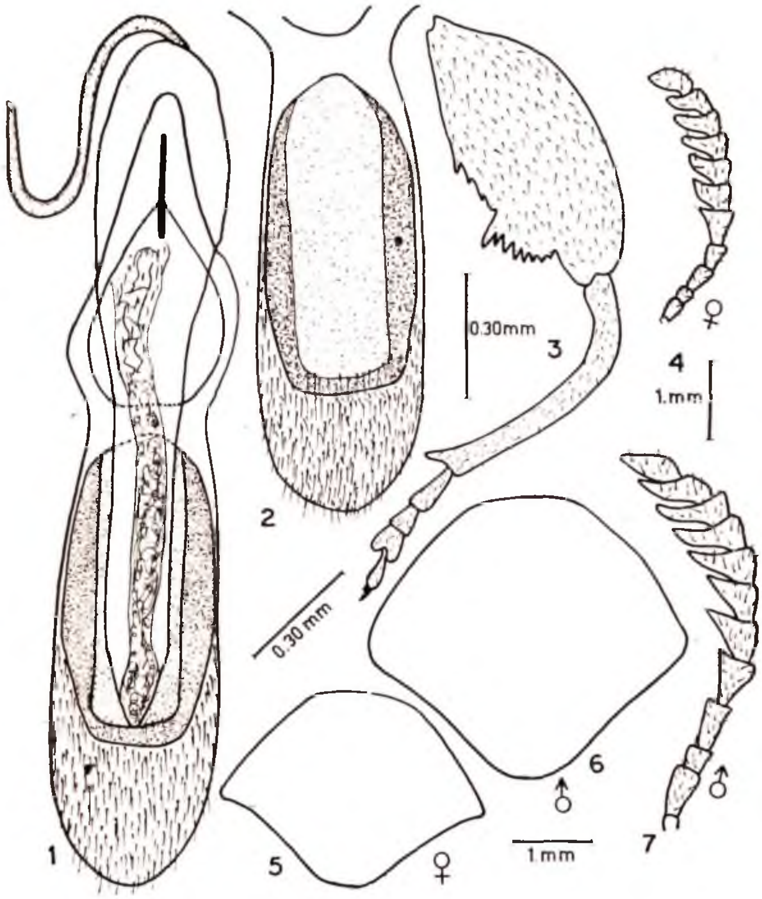
1974 *Caryopemon* Jekel : Vazirani, Bomb. Nat. Hist. Soc. 72(3), 754. Type-species : *C. hieroglyphicus* Jekel.

Head elongate, malar space longer than broad, temples strongly produced behind eyes; eyes finely facetted, emarginate for half length, pronotum less flattened, lateral margins depressed, its hind margins semicircularly produced between the elytra and unisinuate; scutellum minute; elytra flattened with humeral callosities prominent, not much narrowed apically nor bent down, not covering the base of pygidium; parameres completely fused, forming a boat shaped structure; ventral valve absent.

Caryopemon hieroglyphicus Jekel

1855 *Caryopemon hieroglyphicus* Jekel Insecta Saunders. 1 : 27, I f.3,

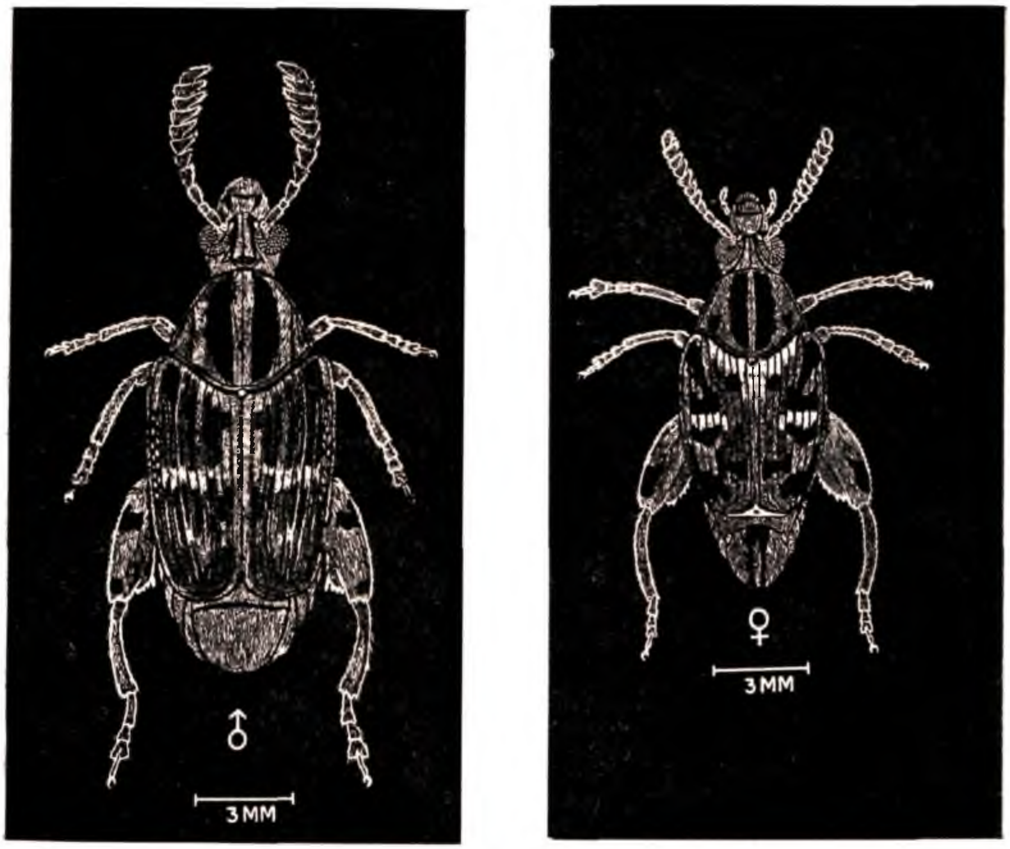
Head black, elongate nearly three times as long as broad behind eyes; frons carinate, roughly punctate between eyes; its surface covered with yellowish pubescence, eyes finely facetted, bulbous, emarginate in front for



Explanation of Figs. *Caryopemon hieroglyphicus* Jekel : 1. Phallus; 2. Parameres; 3. Hind leg; 4. Antenna (female); 5. Pronotum (female); 6. Pronotum (male); 7. Antenna (male).

about half their length; canthus narrow and shallow, its surface covered with dense yellowish pubescence; temple nearly half length of diameter of eye. Antennae black, longer in male than in female, surpassing base of pronotum, strongly serrate in male, segment first nearly two times as long as second in male, not in female, segments 1 to 4 cylindrical, longer than broad, segments 5 to 10 serrate, broader than long, segment 11 conical.

Pronotum black, almost twice as broad as long at base, narrowed in front and regularly convex, its surface sparsely and roughly punctate, covered with pale yellowish setae leaving a pair of longitudinal black areas in middle separated by a median streak, latter broader in male than female. Scutellum black and minute. Elytra long, broad anteriorly and a little narrowed distally, together forming a deep emargination in



Figs 8 and 9. *Caryopemon hieroglyphicus* Jekel : Male and female respectively.

middle for accommodating median lobe of pronotum, with humeral callosities rounded and moderately protruding surface covered with dull white setae in male and by a mixture of dull white and light brownish setae in female, elytral pattern of male consisting of three transverse bands running basally before middle and after middle across seventh striae, together rows of white setae along punctured striae, elytral pattern in female marked by a denser clothing of whitish setae near base and light brownish setae on rest of surface, interrupted by a broad transverse band of whitish setae in middle between striae 5 to 8. Legs black, hind femur extremely large, thick, flattened, compressed laterally, bearing a large tooth beyond middle followed by 7 smaller teeth, preceded by 4 small serrulations; hind tibia parallel sided, strongly curved and grooved bearing terminally a strong dent. Pygidium narrow, vertical in male and sub-vertical in female, its surface uniformly covered with dull white setae in male and pale white setae in female interrupted by a median black area bearing sparse setae.

Phallus 2.00 mm long; parameres totally fused to form a sclerotized boat shaped structure to accommodate exophallic and endophallic tubes in repose in its middle, its apical fused part densely beset with small setae; ventral valve absent; exophallic tube long and sclerotized.

Length male 15.00 mm; Length female 12.15 mm. Locality: 1 Male collected from United Prov., Dehradun, 2300 feet on bush in September 1930 by P. V. Ramany and 1 female from Dehradun in 14.vii 1927 collected by O. C. Ollenbach (No. 408) and determined by G. E. Bryant as *C. hieroglyphicus* Jekal were examined.

Acknowledgements : The author is high'y thankful to Late Professor G. L. Arora for his useful suggestions and encouragement. Thanks are also due to Head of Zoology Department, Punjab University, Chandigarh, India and the Director, FRI Dehradun and PL 400 research grant programs, USA, for research facilities. I also thank Prof. H. R. Pajni, Department of Zoology, Punjab University for constant help and guidance.

REFERENCES

Bridwell, J. C. (1929) A preliminary generic arrangement of palm bruchids and allies (Coleoptera) with description of new species. *Proc. ent. Soc. Wash.*, **31**(2), 37—44.

Jekel, H** (1855) *Insect Saundersiana Curcul.* **1**, 25—29.

** Original not seen.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 219 *to* 221

TAXONOMIC STUDIES OF GENUS *SULCOBRUCHUS* CHUJO FROM INDIA (COLEOPTERA : BRUCHIDAE)[1]

SHIV K. SINGAL

Department of Entomology, Haryana Agricultural University, Hisar (Haryana), India 125 004

(Received 3 January 1986)

Sulcobruchus maculatithorax (Pic) Comb. Nov. is redescribed giving its detail characteristics and illustrations for easy identification. A key to the Indian species of genus *Sulcobruchus* is given with information on additional localities and host plants of *S. kingsolveri* Arora

(Key words : S. maculatithorax. Comb. Nov., ventral valve, phallus, parameres)

Chujo (1937) erected the genus *Sulcobruchus* for the type *S. sauteri* (Pic). Arora (1977) described *S. kingsolveri* from Nahan (HP) and Ram Nagar (UP) and recorded the host-plants *Albizzia* sp. and confirmed its occurrence for the first time in India giving the differences from type species. Pic (1928) had earlier described *Bruchus maculatithorax* from India which is being transferred and assigned to current genus *Sulcobruchus* Chujo after examination of type specimens located at FRI., Dehradun, India and Museum National D' Histoir Naturelle, Paris. *Sulcobruchus maculatithorax* (Pic) Comb. Nov. is redescribed giving characteristics and illustration of genital structures for easy identification, which were not adequately described earlier. Additional information on host-plants and distribution in India on *S. kingsolveri* Arora is also included.

Genus *Sulcobruchus* Chujo.

1937 *Sulcobruchus* Chujo, Trans. Nat. Hist. Soc. Formosa. 27. 189—201.

Type-species *S. sauteri* (Pic)

[1]Part of PH.D. Programme.

Hind femur thick, with its lower surface sulcated, sulcation becoming gradually deep towards apex, inner and outer carinae without any tooth, hind tibiae without movable spurs; head with a strong construction behind eyes; pronotum subconical, without lateral teeth and basal calli.

KEY TO THE INDIAN SPECIES OF *SULCOBRUCHUS* CHUJO

—Antennae unicolourous, testaceous; scutellum longer than broad; pronotum and elytra with definite pattern of setae and dark areas; fore and middle legs entirely testaceous; parameres fused basally to 1/6 of their total length; endophallus provided with a single long sclerotized plate........ .... *maculatithorax* (Pic)

Antennae bicolorous, with first four segments testaceous, rest black; scutellum broader than long, pronotum and elytra without any pattern, uniformly covered with setae; fore and middle legs testaceous, with bases of femora and tips of tarsi black; parameres fused basally upto 1/4 of their total length; endophallus provided with six small triradiate plates and a large spear shaped plate in middle............. ....*kingsolveri* Arora

Sulcobruchus maculatithorax (Pic) Comb. Nov.

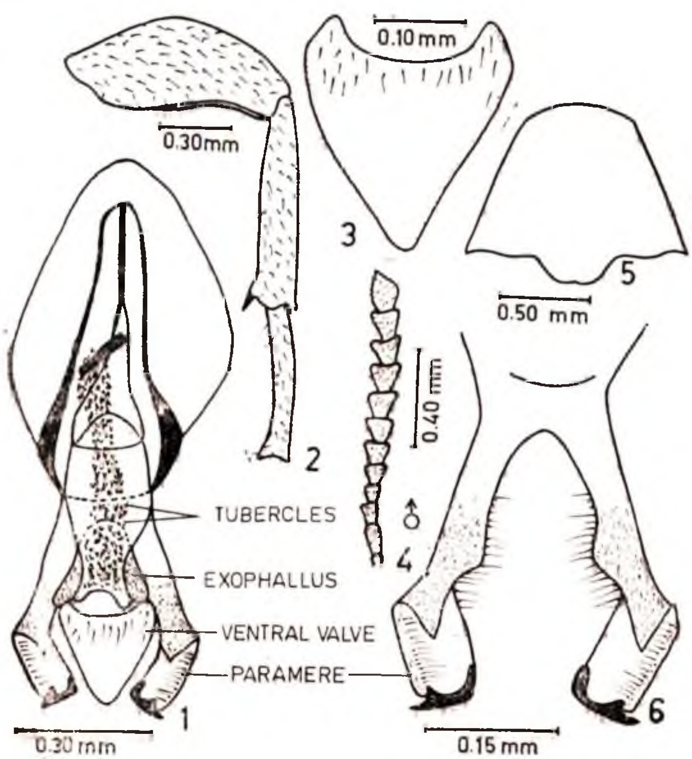
1928 *Bruchus maculatithorax* Pic. Ann. Mag. Nat. Hist. London (10) 1, 298.

1951 *Bruchus maculatithorax* Pic: Mukerji and Chatterji, Indian J. Ent., 13, 14.

1974 *Bruchus maculatithorax* Pic : Vazirani, Bomb. Nat. Hist. Soc. 72(3) : 744.

Head dark brown, slightly broad posteriorly frons carinate, area raised between and behind eyes, its surface densely covered with pale white setae; eyes large, bulging, emerginate in front; canthus shallow and narrow, its surface bearing pale white pubescence. Antennae testaceous, just reaching the base of pronotum, segments 1 to 3 cylindrical, segments 4 to 10 nearly as long as broad, serrate, segment 11 conical.

Pronotum dark brown, sub-conical, broader at base, narrowed anteriorly, pitted, its surface with a large anterior dark area and a pair of large dark areas in the middle, remaining areas uniformly covered with pale-yellowish setae; scutellum black, longer than broad, bifid posteriorly, its surface covered with yellowish setae; elytra dark brown, together longer than broad, not covering pygidium, with a pair of tubercles at the base of 3rd and 4th striae on each elytron, surface of elytra with two pairs of basal elongated more or less rectangular dark areas and two rounded apical dark areas and a row of



Explanation of Figs. *Sulcobruchus maculatithorax* (Pic) Comb. nov : 1. Phallus; 2. Hind leg; 3. Ventral valve; 4. Antenna; 5. Pronotum; 6. Parameres.

Fig. 7. *Sulcobruchus maculatithorax* (Pic) (Male).

small rectangular areas in front of apical dark areas, with elongated spots of yellowish setae in between; fore and middle legs testaceous; hind legs black, hind femur sulcated and bicarinate below, carinae without any tooth; hind tibia strongly produced apically into a dent; pygidium dark-brown, oblique, longer than broad, its surface uniformly beset with yellowish setae.

Phallus 1.15 mm long; parameres characteristic, broad, fused at their bases upto 1/6 of total length, with tips more sclerotized, apical part of each carrying setae on outer and inner margins; endophallus long, studded with minute weakly sclerotized tubercles, also provided with a single long sclerotized plate; ventral valve more or less shield shaped, basal part beset with a number of small setae.

Size moderate : Length male 3.90 mm.

Host plant : *Dalbergia paniculata* (Family Leguminosae)

Locality : Several specimens were examined at Museums FRI Dehradun India and Paris, France. These specimens were being collected from the following places in India : Fraserpet Coorg (Karnatka) (FRI., Sandal Insect Survey) and from Uttar Pradesh at Janakpur, Gonda by R. S. Troup on 14.v.1911.

Sulcobruchus kingsolveri Arora

1987 *Sulcobruchus kingsolveri* Arora, Oriental Ins. suppl. 7, 86.

Host-plants : *Dalbergia fusca* and *D. lanceolaria* (Family Leguminosae). Following new localities were recorded from India in addition to already reported by Arora (1977), KARNATKA; Banglore, Bannerghetta, 1 male, 2 female 12.i.1976, S. K. Singal TAMILNADU : MADRAS : 1. male, 1 female 12.1975, S. K. Singal, Ootaccamund, 1 female, 2.i.1976, S. K. Singal, ORISSA : Bhubaneshwar, Ouat, 2 males, 2 females, 4.i.1977, S. K. Singal.

Acknowledgements: The author is highly thankful to Late Professor G. L. ARORA and Head of Zoology department, Panjab University, Chandigarh, India for providing necessary facilities. My thanks are also due to professor H. R. PAJNI Department of Zoology for constant encouragement and useful suggestions.

REFERENCE

ARORA, G. L. (1977) Taxonomy of the Bruchidae (Coleoptera) of North-West India. Part I Adults. *Oriental Ins. Suppl.* 7, 1—132. Phots 1 to 48. Plates. 48.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp:* 223 *to* 225

BRIEF COMMUNICATION

STUDIES ON POISON BAITING FOR THE TOBACCO CATERPILLAR, *SPODOPTERA LITURA* FB

N. DHANDAPANI[1], A. ABDUL KAREEM[2] & S. JAYARAJ[3]

Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India 625 104

(Received 14 July 1984)

A suitable and effective poison bait was developed for the control of tobacco caterpillar, *Spodoptera litura* Fb. (Noctuidae : Lepidoptera). A comparison was made with various insecticides viz., carbaryl, DDT, fenpropathrin and trichlorphon with rice bran as base and jaggery as attractant. Both laboratory and field experimental results revealed that baiting with trichlorphon or fenpropathrin can be included as an effective integrated pest management measure for this polyhagous pest, in as much as it resulted in effective control of the pest.

(Key words: Spodoptera litura, poison bait, trichlorphon, fenpropathrin)

The polyphagous noctuid pest *Spodoptera litura* Fb. is reported to feed on 112 species belonging to 44 families of food plants (CHARI & PATEL, 1983). This pest became a serious threat to cotton, chillies, sunflower, groundnut, banana and pulses in several parts of Tamil Nadu during the past five years. Even repeated applications of chemical insecticides failed to check the menace completely. Hence an integreted pest management system was felt essential for checking this notorius pest. Poison baiting is one of the methods of the integrated control as in the case of *Agrotis ipsilon* (MESZAROS & NAGY, 1968) and *Amsacta albistriga* (DHANDAPANI & ABDUL KAREEM, 1983). Baiting with nuclear polyhedrosis virus was already tried for this pest (JAYARAJ *et al.*, 1980). The present study was undertaken to evaluate a suitable poison bait for the control of this pest and the results obtained are discussed here.

The baits were prepared by mixing finely powdered base materials viz., rice bran (5 kg) with jaggery (500 g) and used with various insecticides individually viz., carbaryl (Sevin 50 WP) @ 500 g, DDT 50 WP @ 500 g, fenpropathrin (Meothrin 20 EC) @ 50 ml and trichlorphon (Dipterex 50 EC) @ 100 ml per acre. Sufficient quantity of water was added and small balls each weighing about 20 g were made as suggested by PARASURAMAN (1979). Baits prepared in this manner with various insecticides were tested separately for their effectiveness on fourth instar larvae of *Spodoptera litura* by placing four baits ball along the inner periphery of the round glass trough (60 × 30 cm) at equal distances. One hundred larvae of fourth instar stage were released at the middle of the each trough. The number of larvae attracted, affected and killed were recorded at 15, 30, 60 and 120 minutes

[1,3]Department of Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore 641 003.

[2] Tamil Nadu Rice Research Institute, Tamil Nadu Agricultural University, Aduthurai.

Table 1. Effect of baits mixed with insecticides on the larval mortality of *S. litura.*

Bait mixed with	% kill (after)								
	laboratory test (mts)				field test (h)				
	15	30	60	120	1/2	1	2	4	16
Carbaryl 50 WP	0.00 (1.81)	0.00 (1.81)	28.00 (35.27)	78.00 (60.67)	0.00 (0.71)	0.00 (0.71)	5.50 (2.29)	15.00 (3.78)	28.00 (4.12)
DDT 50 WP	0.00 (1.81)	0.00 (1.81)	20.00 (31.95)	70.00 (56.55)	0.00 (0.71)	3.00 (1.56)	6.00 (2.89)	14.00 (3.73)	26.14 (4.38)
Fenpropathrin 20 EC	30.00 (36.46)	50.00 (54.63)	100.00 (90.00)	100.00 (90.00)	8.13 (2.59)	15.00 (3.78)	17.00 (3.91)	30.13 (5.07)	54.71 (5.83)
Trichlorphon 50 EC	25.00 (33.15)	98.00 (83.62)	100.00 (90.00)	100.00 (90.00)	5.00 (2.19)	10.00 (3.21)	28.00 (4.14)	33.14 (5.71)	41.53 (6.92)
Control	0.00 (1.81)	0.00 (1.81)	0.00 (1.81)	0.00 (1.81)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
CD ($P = 0.05$)	2.11	4.93	6.75	3.98	2.01	2.31	2.35	1.79	1.14

(Figures tn parentheses are transformed values).

after release. The experiment was replicated four times. One field experiment was also conducted at Utchappatti village in Madurai district where there was a severe attack on cotton crop. Baits with different insecticides (Table 1) were randomly placed inside the field at twenty places. The field experiment was started at 4.00 P M and counts on number of larvae attracted/killed were taken at 4.30 P M (1/2 h), 5.00 P M (1 h), 6.00 P M (2 h) 8.00 P M (4 h) and next day 8.00 A M (16 h) after placement.

The laboratory experiment (Table 1) revealed that the bait with trichlorphon was found to be highly effective both by contact and feeding. The symptomatological observations such as gittering, restlessness and moving of head side to side were noticed in the caterpillars within 5 minutes and further feeding was stopped. Ninety eight per cent mortality occurred within 30 minutes after feeding. In the case of fenpropathrin, 100 per cent mortality occurred within 60 minutes after feeding which was on par with the trichlorphon. Baiting with carbaryl and DDT gave only 78 and 70 per cent mortality respectively after two hours of feeding. But during earlier periods only baiting with carbaryl was recommened.

In the field experiment, only the well grown late instar larvae were attracted to baits, these caterpillars moved out from soil crevices and other hideouts and by migrating from plants. A maximum of 41.53 caterpillars were killed by a single ball of the bait with trichlorphon 60 EC (Table 1) after 16 of placement which was on par with baits prepared with fenpropathrin. However, within one hour after placement fenpropathrin gave mortality of 15 caterpillars, whereas carbaryl and DDT were statistically inferior in effectiveness. Since the prestarved

larvae were confined in the glass trough in the laboratory experiment, the attraction and death of larvae were quick, but under field conditions, the maximum attrativity of baits was seen at 16 h after placement. Hence, it could be concluded that in practice, keeping poison baits with fenpropathrin or trichlorphon may be useful for control of *S. litura* as a tool in the integrated pest management system.

Acknowledgement: The financial support by M/S. Hindustan Lever Research Foundation, Bombay, s acknowledged.

REFERENCES

Chari, M. S. & S. N. Patel (1963) Cotton leafworm *Spodoptera litura* Fabricius : its biology and integrated control measures. *Cotton Dev.*, **13**, 7—8.

Dhandapani, N. & A. Abdul Kareem (1983) Poison bait for red hairy caterpillar. *TNAU Newsl.*, **13** (2), 1.

Jayarj, S., S. Santharam, K. Narayanan, K. Soundararajan & R. Balagurunathan (1980) Effectiveness of the nuclear polyhedral virus aginst field populations of the tobacco caterpillar *Spodoptera litura* on cotton. *Andhra agric J.*, **27** (1 & 2), 26—29.

Meszaros, Z. & B. Nagy (1968) Outbreak of the black cutworm *(Scotia ipsilon* Hufn) in Hungary and comments on migration of adults. *Acta Phytopath. Acad. Sci. Hung.*, **3**, 261—265.

Parasuraman, S. (9179) Studies on the ecology of tobacco caterpillar *Spodoptera litura* (F.) (Lepidoptera : Noctuidae). M. Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore. 64 pp.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 227 to 229

REPORTS AND NEW RECORDS

NEW RECORD OF SCALE INSECTS (DIASPIDAE : HOMOPTERA) AND AN APHELINID PARASITE (HYMENOPTERA) FROM KASHMIR INDIA

M. AMIN MASOODI & A. R. TRALI

Division of Entomology, S. K. University of Agricultural Sciences and Technology, Lalmandi, Srinagar, India 190 008

(Received 6 February 1986)

Two species of scale insects viz., *Lepidosaphes kirgisica* Borchsenius and *Chionaspis salicis* Linnaeus, infesting *Salix* spp. are recorded for the first time from India. Also, an ecto-parasite, *Aphytis paramaculicornis* DeBach and Rosen has been reared from *L. kirgisica*.

(Key words : new records, Diaspid scales, aphelinid parasite)

During the course of survey for scale insects and their natural enemies in Jammu and Kashmir State, two diaspid scales-oystershell scale, ***Lepidosaphes kirgisica*** Borchesenius and scurfy scale, ***Chionaspis salicis*** (Linnaeus) have been encountered for the first time from this region. These species are new records for India.

L. kirgisca was found to affect *Salix fragilis* at Largooh, Anantnag in Kashmir valley. A hymenopteran ectoparasite, *Aphytis paramaculicornis* DEBACH& ROSEN belonging to the family Aphelinidae has been reared from this scale insect. The extent of paresitisation was observed to be between 3.50 to 5.80 per cent. The development of the scale on pumpkins in the laboratory was found very slow as compared so San Jose Scale, *Quadraspidiotus perniciosus* (Comstock).

C. salicis has been found to attack *Salix* sp. at Shey in Ladakh. However, no parasite could be reared from this scale insect species.

Earlier, apart from San Jose scale *Quadraspidiotus perniciosus* (Comstock) (FLETCHER 1919; FOTEDAR 1941; MALIK *et al.*, 1972), *Aspidiotus destructor* was recorded on mango (FOTEDAR & KAPUR, 1941) in Jammu and Kashmir.

Acknowledgement : The authors are thankful to Prof. A. AHMAD, Vice-Chancellor and Mr. M. A. DAR, Director Research, S. K. University of Agricultural Sciences and Technology, Srinagar for providing necessary facilities. Thanks are also due to the specialists of Commonwealth Institute of Entomology, London for identifying the specimens.

REFERENCES

FLETCHER, T. B. (1919) Report of the proceedings of the second Entomological Meeting held at Pusa, February 5—12. Supt. Govt. Printing Calcutta.

FOTEDAR, M. R. (1941) San Jose scale and its control in Kashmir. *Indian Farming*, 2, 234—237.

FOTEDAR, R. M. & A. D. KAPUR (1941) *Aspidiotus destructor* as a pest of mango at Jammu (Kashmir). *Indian J. Ent.*, 3(1), 142.

MALIK, R. A., A. A. PUNJABI & A. A. BHAT (1972) Survey study of insect and non-insect pests in Kashmir. *Horticulturist* (J&K), 3 (1—3), 29—44.

ERIBORUS ARGENTEOPILOSUS (CAMERON) - A NEW PARASITE OF *LEUCINODES ORBONALIS* GUEN

G. C. TEWARI & H. R. SARDANA

Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, India 560 089

(Received 27 February 1985)

Eriborus argenteopilosus (Cameron) (Hymenoptera: Ichneumonidae) was reported for the first time as larval parasite of *Leucinodes orbonalis* Guen infesting eggplant during rainy season, 1985. The extent of natural parasitization was low ranging from 0.53 to 2.0 percent.

(Key words : Eriborus argenteopilosus, Leucinodes orbonalis, larval parasite)

The larvae of ***Leucinodes orbonalis*** Guen (Lepidoptera : Pyralidae) infesting eggplant were found parasitized by ***Eriborus argenteopilosus*** (Cameron) (Hymenoptera :

Fig. 1. Adult parasite *Eriborus argentiopilosus*.

Ichneumonidae) at the experimental farm of the Indian Institute of Horticultural Research, Bangalore, for the first time in the rainy season of 1985. Adults of parasite (Fig. 1), black in colour were very active. The natural parasitization was, however, low ranging from 0.53 per cent to 2.0 per cent during September—October 1985.

Earlier, *E. argenteopilosus* has been recorded on *Spodoptera exigua* (Hubner) in Gujarat (PATEL *et. al.* 1971) *Heliothis armigera* (Hubner) infesting cotton and pigeonpea in Marathwada (BILAPATE, 1981) and safflower caterpillar *Prospalta (Prigea) capensis* Guen in Central India (PALIWAL & JAKHMOLA, 1981).

Acknowledgement. The authors are thankful to Dr. I. D. GAULD of the British Museum (Natural History), London for the identification of the parasite.

REFERENCES

BILAPATE, G. G. (1981) Investigations on *Heliothis armigera* (Hub) in Marathwada, 23. Key mortality factors on cotton, pigeonpea and chickpea. *Proc. Ind. Nat. Sci. Acad*, **B 74** (5), 637—646.

PALIWAL, K. L. & S. S. JAKHMOLA (1981) Role of parasites and pathogen in the natural control of safflower caterpillar, *Perigea capensis* Guen. *J. Bombay Nat. His. Soc.*, **78** (2), 410—412.

PATEL, R. C., J. C. PATEL & J. K. PATEL (1971) New records of the parasites of *Spodoptera exigua* (Hub.) and *S. litura* (F.) from Gujarat. *Indian J. Ent.* **33** (1), 92—93.

RECORD OF *APHIS CRACCIVORA* KOCH. AND *APHIS GOSSYPII* GLOV. (FAM : APHIDIDAE) ON *MOGHANIA MACROPHYLLA* A HOST PLANT OF LAC INSECT

A. K. SEN, A. BHATTACHARYA & S. C. SRIVASTAVA

Division of Entomology, Indian Lac Research Institute, Numkum, Ranchi, Bihar, India

(Received 13 December 1985)

Aphis craccivora Koch and *Aphis gossypii* Glov, have been recorded for the first time on the bushy lac host, *Moghania macrophylla*. This affects the production of lac by way of damaging the host.

(Key words : Aphis craccivora Koch., *A. gossypii* Glov. pest, *Moghania macrophylla* O. Ktze, and lac host).

Aphis craccivora Koch and *Aphis gossypii* Glov. were first observed on *Moghania macrophylla* O. Ktze. during 1982 but during 1983—1984 it was found to be a considerably serious pest of this bushy lac host. These two species of aphids are known to be the pests of most of the common vegetables, fruits, cereals, pulses, fibre crops, oil seeds and ornamental plants, but for the first time it has been recorded as a pest of *M. macrophylla*.

During studies on culture of lac insect, *Kerria lacca* (Kerr) on *M. macrophylla* in the experimental area of the Institute, it was observed that the tender shoots, foliage, inflorescence and pods of more than 15—20 per cent plants were having moderate to heavy infestation of both *A. craccivora* and *A. gossypii* and both the species of aphids were observed to occur side by side on the same host plant. The pods had a heavier infestation than the other parts of the plant. On an average 330 adults and nymphs per shoot were found on the infested parts (Fig. 1). As a result of infestation there was premature leaf fall; wilting of young shoots, drying of immature pods and flowers and thus affecting the production of lac by damaging the host to a sizeable extent.

Fig. 1. Photograph showing the infested parts of *M. macrophylla* plant.

A review of literature revealed that the above two species of aphids have a number of other leguminous hosts. It is assumed that these aphids infesting *M. macrophylla* plants which also is a member of the same family, might have migrated from some other leguminous plant possibly *Cajanus cajan*, which is now being extensively grown in the experimental area since 1980 onward.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 231 *to* 233

AN OVIPOSITION STIMULANT IN THE MALE ACCESSORY GLAND EXTRACT OF *SPODOPTERA LITURA* (LEPIDOPTERA – NOCTUIDAE)

R. SRIDEVI, APARNA RAY & P. S. RAMAMURTY

School of Life Sciences, University of Hyderabad, Hyderabad, India 500 134

(Received 2 June 1986)

The male accessory glands of *Spodoptera litura* have an oviposition stimulating factor. The effect of mating can be partially mimicked by injection of extracts of the male accessory gland to virgin female moths.

(*Key words:* male accessory gland, oviposition stimulant)

INTRODUCTION

Mating is known to increase fecundity in a number of insect species. There are several reports in Dipterans and Orthopterans on the stimulatory effect of male accessory gland substance on oviposition in virgin females (LEOPOLD, 1976; FRIEDEL & GILLOTT, 1976; LANGE & LOUGHTON 1985).

Little information is available on the role of mating in oviposition behaviour in lepidopterans. In *Hyalophora cecropia* (TRUMAN & RIDDIFORD, 1971; RIDDIFORD, & ASHENHURST, 1973) it has been shown that deposition of spermatozoa into the bursa copulatrix triggers the release of an oviposition stimulating hormone from the intrinsic cells of the corpus cardiacum. The presence of an oviposition stimulating substance in the male reproductive tracrt of *Bombyx mori* has been reported by YAMAOKA & HIRAO (1977). The present communication reports the effect of male accessory gland extract on oviposition in *Spodoptera litura*.

MATERIALS AND METHODS

Freshly emerged female virgin moths were used in all cases. Three groups were set up for study. In the first group virgin female moths were injected $50 \mu l$ of accessory gland extract (protein concentration $50 \mu g / 50 \mu l$ of insect Ringer) equivalent to 1/15th pair of accessory gland. In the second group virgin female moths were injected with $50 \mu l$ of insect Ringer. The third group having virgin female moths along with fresh males served as normal controls. Intra-abdominal injections were given to the female moths 10 hours after eclosion and the oviposition test started soon after injection. For each experiment the insects were kept in standard rearing cages and fed on dilute honey solution. The cages were checked regularly for egg laying.

The preparation of accessory gland extract:-

The assessory glands were dissected out from 12 h old males which were collected soon after emergence and maintained separately. The glands were homogenized in cold, insect Ringer. The homogenate was centrifuged at $12{,}000 \times g$ for 10 min at 5°C in a Beckman J2-21 centrifuge. The supernatant was removed and the protein concentration adjusted to $50 \mu g / 50 \mu l$ of insect Ringer.

RESULTS AND DISCUSSION

Injection of $50 \mu l$ of accessory gland extract from 12 h old males, resulted in virgin female moths laying eggs within

TABLE 1. Effect of male accessory gland extract on oviposition in virgin female moths of *Spodoptera litura*.

Group	treatment	time of egg laying	average No. of eggs laid / insect
I Virgin female moths	$50 \mu l$ of accessory gland extract injected	24h + 48h — 72h —	206 ± 91
II Virgin female moths control	$50 \mu l$ of insect Ringer injected	24h — 48h — 72h +	222 ± 93
III Normal controls (allowed to mate)	—	24h — 48h + 72h —	414 ± 114

'+' indicates the time of egg laying. Each group consisted of four sets having four female moths in each set.

24 hours. The virgin moths serving as controls, injected with $50 \mu l$ of insect Ringer did not lay eggs till 72 hours post injection. Normal control female moths laid eggs by 48 hours. NAVON & MARCUS (1982) have already reported that mating and transfer of spermatophore occurs between 4 to 14 hours after adult emergence. The number of eggs oviposited by normal mated females however is much higher than the number of eggs oviposited by the female moths of the first two groups (Table 1). The mating was either confirmed by the presence of sperms in spermatheca of females or by checking the hatchability of the eggs laid. The eggs laid by the virgin females, injected with accessory gland extract did not hatch.

Our results show that normal controls lay eggs much earlier than the insect Ringer injected virgin female moths, showing that mating has an accelerating effect on oviposition. Injection of gland extracts from mature males induced oviposition in virgin female months. This implies the presene of an ovipositon stimulating factor in the accessory glands which is presumably passed on to the females via mating through spermatophores (TAKEUCHI & MIYASHITA, 1975).

The virgin female moths injected male accessory gland extract lay eggs earlier than the mated females of the same age group and this is probably due to the direct injection of the stimulating factor into the haemocoel (YAMAOKA & HIRAO, 1973, 1977). The number of eggs laid by the female moths injected with the accessory gland extract and the control virgin female moths are more or less the same; they are however esser than the number of eggs laid by he normal control females (TRUMAN & tRIDDIFORD, 1971). Thus the act of mating may in itself exert some degree of stimulation, although it is certainly not the only and perhaps primary stimulus for oviposition (PICKFORD *et al.*, 1969).

Acknowledgements: R S thanks the C S I R, New Delhi, for the research fellowship. Thanks are due to the Director CTRI, RAJAHMUNDRY, A P, for kindly providing us with a nuclear culture of *Spodoptera litura*. We thank Mr. S. NAGESWAR RAO for his help in the maintenance of the insect culture.

REFERENCES

FRIEDEL, T., & C. GILLOTT (1976) Male accessory gland substance of *Melanoplus sanguinipes*, an oviposition stimulant under the control of the corpus allatum. *J. Insect Physiol.*, **22**, 489—495.

LANGE, A. B. & B. G. LOUGHTON (1985) An oviposition stimulating factor in the male accessory reproductive gland of the locust *Locusta migratoria*. *Gen. Comp. Enocrinol.*, **57**, 208—215.

LEOPOLD, R. A. (1976) The role of male accessory glands in insect reproduction. *A. Rev. Ent.*, **21**, 199—221.

NANON, A. & R. MARCUS (1982) D- Isoascorbic acid fed to *Sodoptera littoralis* moths induces sterility due to spermatophore malformation. *J. Insect Physiol.*, **28**, 823—828.

PICKFORD, R., A. B. EWEN & C. GILLOT (1969) Male accessory gland substance, an egg-laying stimulant in *Melanoplus sanguinipes* (F) (Orthoptera, Acrididae). *Can. J. Zool.*, **47**, 1199—1203.

RIDDIFORD, L. M. & J. B. ASHENHURST (1973) The switch over from virgin to mated behaviour in female cecropia moths : The role of ihe bursa copulatrix. *Biol. Bull.*, **144**, 162—171.

TAKEUCHI, S. & K. MIYASHITA (1975) The process of spermatophore transfer during the mating of *Spodoptera litura* F. *J. Appl. Ent. Zool.*, **19**, 41—46.

TRUMAN, J. W. & L. M. RIDDIFORD (1971) Role of the corpus cardiacum in the behaviour of saturnid moth. II. Oviposition. *Biol. Bull.*, **140**, 8—14.

YAMAOKA, K. & T. HIRAO (1973) The relationship between oviposition and spontaneous discharge of motor neurons in *Bombyx mori*. *J. Insect Physiol.*, **19**, 1277—1283.

YAMAOKA, K. & T. HIRAO (1977) Stimulation of virginal oviposition by male factor and its effect on spontaneous nervous activity in *Bombyx mori*. *J. Insect Physiol.*, **23**, 57-63.

Entomon, 1987, *Vol.* **12**, *No.* 3, *pp.* 235 *to* 239

β-GLUCURONIDASE (EC 3.2.1 31) ACTIVITY DURING METAMORPHOSIS OF *TRIBOLIUM CASTANEUM* (HBST) AND *T. CONFUSUM* (DUVAL)

VILAS D. ARABALE

D. B. F. Dayanand College of Arts and Science, Solapur, India 413 002

(Received 12 September 1986)

β-Glucuronidase activity was estimated biochemically during the metamorphosis of the two species of *Tribolium*. The enzyme showed statistical changes in its activity during different stages of development. During most of the larval period (L_1 to L_4) it showed a low level of activity. The peak enzyme activity was observed during the pupal (P_3) period. The freshly emerged imago exhibited decreased level of activitiy while the empty puparia contained an appreciable quantity of the enzyme. The two species exhibited practically the same trend of the enzyme activity. The results obtained were interpreted with reference to the metamorphic events and compared and discussed with the available literature.

(Key words: Tribolium species, β-glucuronidse, lysosomal, puparia).

INTRODUCTION

The existence of lysosomes in insect tissues and their possible role during metamorphosis has excited interest among many workers. Of the several lysosomal acid hydrolases, alteration in acid phosphatase (BARKAR & ALEXANDER, 1958; NATH & BUTLER, 1971) and esterases (MATVEEVA & KOROCHKIN, 1974; KAUR & RAVI PRAKASH, 1979) during metamorphosis of many insects have been worked out. Moreover, acid phosphatase is commonly used as a marker enzyme for the demonstration of the lysosomes. However, among the insects, very little is known regarding the activity of β-glucuronidase. Therefore, in the present investigation an attempt has been made to study biochemically the activity of β-glucuronidase during the postembryonic development of the two species of *Tribolium*. The study would be useful in understanding the functional involvement of the enzyme during insect metamorphosis.

MATERIALS AND METHODS

Different stages of larvae, pupae, freshly emerged adults and full grown adults of *T. castaneum* and *T. confusum* were selected for the study. On the basis of size and morphological characters the larval period was divided into five (L_1 to L_5) stages and the pupal period into three stages, viz., early pupa (P_1), mid pupa (P_2) and late pupa (P_3). The L_4 stage is a full grown wandering stage while L_5 is quiescent and transitory stage; therefore, this is considered as a distinct continuation of the full fed ultimate instar.

After isolation from the culture medium, the above stages were properly cleaned, the larvae and adults were immobilized by cold treatment and were then utilized for the enzymatic study. β-glucuronidase activity was estimated by the method of of FISHMAN (1967). Phenolphthalein mono β-D-glucuronic acic (0.001 m) was employed as a substrate. The enzyme activity was expressed in Fishman

units (F U) as μg phenolphthalein liberated per mg of protein.

RESULTS

β-glucuronidase exhibited appreciable quantities of activity among the different stages of the insects under study. The enzyme units obtained in each stage of the development are given in the Table 1.

During metamorphic events of *T. Castaneum* the average enzyme activity ranged between 109.38 ± 10.79 to 1177.0 ± 75.04 FU. It remained low and more or less constant during larval development with slight increase at L_4 stage. This increase was about three-fold when compared with the activity at L_1 stage. A further increase in enzyme content was evident during pupal development, reaching the maximum at P_2 stage (1177.0 ± 75.04 units). At the end of pupal life (P_3) a slight decrease was observed. Thus, the enzyme showed a steep increase from L_4 to P_2 stage. This increase was about 3.34 fold and it was about 10-fold when compared to the activity at L_1 stage.

There was about 1.72 fold decrease in enzyme level in freshly emerged adults. But in later adult life (upto a week) a gradual increase was observed. Thus, from the Table, the data indicate that maximum activity occurred during pupal (P_2) development.

Practically an identical trend of enzyme activity was observed in *T. confusum*. In it, the values ranged between 114.59 ± 12.07 to 1104.09 ± 41.04 units. Stagewise figures of the enzyme contents are given in the same Table.

The empty puparia of both the species were also subjected for the enzymatic studies and in them, appreciable quantity of the enzyme was seen. In *T. castaneum* it was 585.9 ± 27.6 units and in *T. confusum* 546.84 ± 19.02 units.

The specific activity of the enzyme (Table 1) when calculated in terms of protein was also found to be maximum at P_2 stage in both the species.

DISCUSSION

Biochemical results obtained show statistical changes in β-glucuronidase activity in different stages of both the species. During larval development, from L_1 to L_4 stage, the enzyme shows more or less the same activity. However, it increases abruptly at L_5 stage and continues to increase further to reach maximum level at P_2 stage. After this it shows a decreasing trend till the emergence of the adults. A similar type of behaviour of the enzyme has been shown in other insects by HEGDEKAR & SMALLMAN (1969) and VARUTE & SAWANT (1971).

It is interesting to note that the enzyme contents remain low during larval development (L_1 to L_4) although the size of the larva increases with the successive molts. In contrast to this, the other two acid hydrolases, viz., acid phosphatase and esterase studied presently, increase steadily in their activity during these stages. The cause for such low activity of β-glucuronidase might be due to non-availability of sufficient glucuronides during this phase of development, since glucuronic acid has not been definitely identified in insects (HEGDEKAR & SMALLMAN, 1969). Another cause might be due to the structure-linked latency of the enzyme and its non-lysosomal sites may suggest a structural role. Regarding this, the concept is that during cellular differentiation and proliferation demands for the formation

TABLE 1. β- Glucuronidase activity during the development of *T. castaneum* and *T. confusum*. Values of protein and specific enzyme activity are also indicated. Values are mean ± S. E.

Stage of develop-ment	*T. castaneum*			*T. confusum*		
	enzyme activity (F U)	protein mg / g	specific avtivity	enzyme activity (F U)	protein mg/g	specific activity
L_1	117. 8± 9.25	110.48± 9.32	1.06	125.01±15.51	120.75± 6.01	1.03
L_2	10).38±10.79	138.57± 7.14	0.78	130.22±13.86	142.63± 7.52	0.91
L_3	130. 2±21. 3	187.62±15.82	0.69	114.59±12.07	181. 5± 9.43	0.63
L_4	140.64±11.92	195.85± 6.08	0.71	151.06±15.97	201.35±10.02	0.75
L_5	351.54±15.63	151.25± 7.79	2.32	312.48±16. 7	155.45± 8.19	2.01
P_1	718.70±24. 5	130.06± 5.46	5.52	609.33±30.78	135.77± 7.05	4.48
P_2	1177. 0±75.04	126. 5±10.66	9.30	1104.09±41.04	122. 8± 6.41	8.99
P_3	1072.84±68.39	118. 0± 4.95	9.09	1036.39±74.59	118.76± 5. 9	8.72
FA	682.24±24.39	133.28± 6. 9	5.11	557.25±34. 5	138. 6± 9.32	4.02
A_1	854.11±48.01	145. 6±14.52	5.86	822.86±30.59	148. 8± 7.82	5.52
A_2	916. 6±33. 5	154.95± 4.81	5.91	848. 9±16.79	159.35± 8. 4	5.32

of membranous structures like endoplasmic recticulum (ER) would result in the production of the structural membrane proteins (FISHMAN *et al.*, 1963). In a similar way the enzyme proteins such as β-glucuronidase may be ordered perhaps in association with its respective macromolecular substrates and phospholipids to contribute to the strcture of ER. Such structural proteins formed might remain inactive catalytically so that there could not be any metabolic hydrolysis.

An increase in β-glucuronidase activity similar to acid phosphatase during the late larval stage (L_5) could be attributed to the histolytic events occurring prior to actual metamorphosis (BEAULATON, 1967; VAN PELT-VERKUIL, 1978).

Heightened enzyme activity during pupation could be considered as an adaptive response to the autolytic/histolytic processes taking place during that period. The preparative phase of metamorphosis is initiated during the late larval stage (L_5) and it speeds up during later phase with an increase in lysosomal enzymes (BARKAR & ALEXANDER, 1958; HEGDEKAR & SMALLMAN, 1969; NATH & BUTLER, 1971; VARUTE & SAWANT, 1971). This is further supported by the histochemical results (unpublished) where most of the pupal tissues exhibit granular and intense staining.

Increased β-glucuronidase activity during pupation could further be attributed to a change in structure-linked latency of free and bound forms of the enzyme (HEGDEKAR & SMALLMAN, 1969; VARUTE & SAWANT, 1971; NATH & BUTLER, 1971). The increase in free and soluble

enzyme activity may be taken to indicate lysosomal activation which occurs in two steps: (i) with an increased availability of the enzyme due to an increased permeability of the lysosomal membrane without parallel release and, (ii) due to increased availability of the enzyme with parallel release. The first step leads to the increase in free enzyme activity and second one results in an increased soluble fraction.

To analyse the cause for the fall of enzyme activity at the time of adult emergence, the empty puparia of both the species were subjected to the enzymatic study. The results indicate that they contained an appreciable amount of β-glucuronidase. The histochemical results of the late pupa lend further support. The epidermis of the pupa gets intensely stained just beneath the cuticular wall indicating accumulation of the enzyme within the puparial wall. From its granular nature the lysosomal form of the enzyme could be deduced. Similar observations have been made by VARUTE & SAWANT (1971). Reports on the occurrence of other acid hydrolases in the puparia are also available (BARKER & ALEXANDER, 1958; BERGER & CANTER, 1973; KAUR & RAVI PRAKASH, 1979). It seems that there exists a mechanism of segregation by which the enzyme is eliminated along with the purparial wall after fulfilment of its function during metamorphosis. Regarding this a parallel view has been put forth by VARUTE (1970) and VARUTE & MORE (1971) during anuran metamorphosis.

A gradual increase in enzyme contents during adult life could be related to the synthetic and metabolic activities and to the maturation of the gametes (RAYCHAUDHURI & BUTZ, 1965: DHAND & RASTOGI, 1975). Practically identical trend of the enzyme activity among the two species of *Tribolium* indicates their close relatedness and this can be taken as a useful index in tracing their phylogeny.

Acknowledgement: The present article is an extract from the Ph. D. Thesis. The author is thankful to Dr. NARSIMHA K. MORE, Reader in Entomology, Shivaji University, Kolhapur for his valuable guidence. Thanks are also due to U G C authorities for the award of Teacher fellowship during the tenure of which the work was carried out.

REFERENCES

BARKER, R. J. & B. H. ALEXANDER (1958) Acid and alkaline phospatase in houseflies of different ages. *Ann. ent. Soc. Am.*, **51**, 255–257.

BEAULATON, T. (1967) Localisation d' activities lytiques dans la glands prothoracique Du ver a soie du chene *(Anthroraea pernyi)* all stade premymphal. II. Les vacuoles autolyfigues (cytolysosomes). *J. Microscopic*, **6**, 349-370-

BERGER, E. & R. CANTER (1973) The esterase of *Drosophila*. I. Anodal esterases and their possible role in eclosion. *Dev. Biol.*, **33**(1), 48—55.

DHAND R. K. & S. C. RASTOGI (1975) Acid and alkaline phosphatase activity in relation to egg laying and ageing in *C. analis* (Fab.) (Coleoptera : Bruchidae). *Can. J. Zool.*, 53(11), 1500—1504.

FISHMAN, W. H. (1967) Determination of β-Glucuronidases, 77—149, *in*: *Methods of Biochemical Analysis* (ed. GLICK, D.) vol. **14**, Interscience, New York.

FISHMAN W. H., S. S. GOLDMAN & DELELLI (1963) Dual localization of β-glucuronidase in endoplasmic reticulum, and in lysosomes *Nature;* **213**, 457—460.

HEGDEKAR, B. M. & B. N. SMALIMAN (1969) Intracellular distribution of β-glucuronidase activity during metamorphosis of the house fly, *M. domestica. Can. J. Zool.*, **47**, 45-49

KAUR, P. & RAVI PRAKASH (1979) Ontogenetic esterase isoenzymes and their significance in *Zaprionus parvittiger*. *Indian J. exp. Biol.*, **17**(7), 644--646.

MATVEEVA, N. M. & L. I. KOROCHKIN (1974) The sequence of expression of paternal and maternal esterases in ontogenesis of *D. virilis*. *Ontogenez.* **5**(1), 92—95.

NATH J. & L. BUTLER (1971) Acid phosphatase during development of the black carpet beetle, *Attagenous megatoma* (Feb.). *Can. J. Biochem*, **49**(3), 311—315.

RAYCHAUDHURI, A. & A. BUTZ (1965) Aging. I. Effects of parental age on the life cycle of *T. confusum* (Coleoptera : Tenebrionidae). *Ann. ent. Soc. Am.*, **58**, 535—550.

VAN PELT-VERKUIL, E. (1978) Increase in acid phosphatase activity in the fat body during larval and prepupal development in *Calliphora erythrocephala*. *J. Insect Physiol.*, **24**, 375—382.

VARUTE, A. T. (1970) β-glucuronidase in the liver of tadpoles of *Rana tigrina* during growth and metamorphosis. *Comp. Biochem. Physiol.*, **33**, 149—155.

VARUTE, A. T. & N. K. MORE (1971) β-glucoronidase in the alimentary canal of tadpoles of *Rana tigrina* during growth and metamorphosis. *Comp. Biochem. Physiol.*, **38**, 255—233

VARUTE, A. T. & V. A. SAWANT (1971) β-glucuronidase during embryogenesis, growth and metamorphosis of the larvae of blowfly, *Crysomia rufiferacis*. *Comp. Biochem. Physiol.*, **38**, 211—224.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 241 *to* 245

HISTOPATHOLOGICAL EFFECTS OF HEXACHLOROCYCLOHEXANE (HCH) ON THE OVARY OF ADULT *POEKILOCERUS PICTUS* (FABR.) (ORTHOPTERA : ACRIDIDAE)

JANAK AHI

Department of Zoology, Dr. H. S. Gour Vishwavidyalaya, Saugor (M P), India

(Received 21 February 1986)

The present paper reports the histopathological effect of the experimental concentration of HCH when injected in to female *Poekilocerus pictus* for different time intervals viz., 4 to 16 days. The most striking abnormality was formation multinucleated oocytes, which was due to amitosis. It has been concluded that HCH apart from making the tissues hyperactive and causing various cellular deformations also regulates the amitotic division of the oocyte nucleus

(*Key words:* histopathology, ovary, HCH, *Poekilocerus pictus)*

INTRODUCTION

Organochlorines are broad spectrum and persistent group of insecticides, which are being used to control insects and through recirculation in the environment reach the human beings. Their chronic usage brings about cellular disorders.

The histopathological effects of certain insecticides on different insects have been studied by WOKE (1940), SALKELD (1950), CHADBOURNE & RAINWATER (1953), ELDEEB & ZEID (1961) and SOLIMAN *et al.* (1971). The carcinogenic effect of certain organochlorines has been worked in mammals. They are concerned with tissue stress leading to carcinogenesis (FARBER, 1980).

But as far as the author is aware the affect of HCH on the ovarian tissues of insects has not been described. Thus the present study was undertaken with a view to see if HCH has any tumorogenic effect on insects, specially as NAGASAKI *et al.* (1971) have reported the development of hepatomas in mice treated with BHC.

MATERIALS AND METHODS

The nymphs of *P. pictus* were collected from the fields around Sagar, and were kept in glass fronted cages. Newly moulted insects were kept in separate bottles and marked for their ages. 10 days old adult females were used for the experiment.

Technical grade of HCH (90%) was used for the experiment which was supplied by M/s Union Carbide, Bhopal. The range of isomers is as follows: α -isomer, 55-70%; β -isomer, 6-8%; γ -isomer, 10-18%; δ -isomer, 3-4%; ε -isomer, very small amounts. The insecticlde was dissolved in acetone at a concentration of 1% and diluted further with distilled water prior to the experiment. The concentrations were determined according to the highest rate of mortality with a high dose and doses below it, till the safe concentration was reached which served as the experimental concentration. The females were injected on alternate days with .2 ml of .01% HCH; comparable .1% acetone injected and untreated individuals constituted the controls. Thefemales were vivisected after 4, 6, 8, 10, 12, 14 and 16 days of treatement. At the end

of each experiment the ovary was taken out, washed in physiological saline, fixed in aqueous Bouin's fluid, dehydrated in graded alcohols, cleared in xylene and embedded in paraffin wax (60–62°C). Sections cut at 6μ were stained with haematoxylin-eosin.

The results are based on observations taken in three replicates of 12 insects each.

RESULTS

(a) Control series :

The control series in the present investigations showed no deviation from the normal histology.

(b) Histopathology of the ovaries :

On injecting .2ml of .01% BHC on alternate days revealed quite apparent changes in the ovary which are described as follows :

4 to 8 days :

At 4 days the ooplasm is seen divided into chambers and the nucleus is centrally located whereas in the oocyte of normal *P. pictus* the nucleus is always situated towards the terminal end (Fig. 1). At 6 days the ooplasm is constricted. Binucleated oocytes are seen, the nuclei are situated apart in which the ooplasm is divided into two portions (Fig. 2a); while the nuclei are prominent showing vacuolization, in oocytes in which the ooplasm is a single mass (Fig. 2b). The tunica propria appears distorted and the follicular epithelial cells cannot be distinguished into separate cells. At 8 days, the ooplasm is seen divided into chambers; thus multinucleated oocytes are evident. The follicular epithelial cells are distorted and degenerated except at few places a layer of 4 to 6 cells can be seen (Fig. 3). The epithelium of the genital chamber also shows pycnotic nuclei.

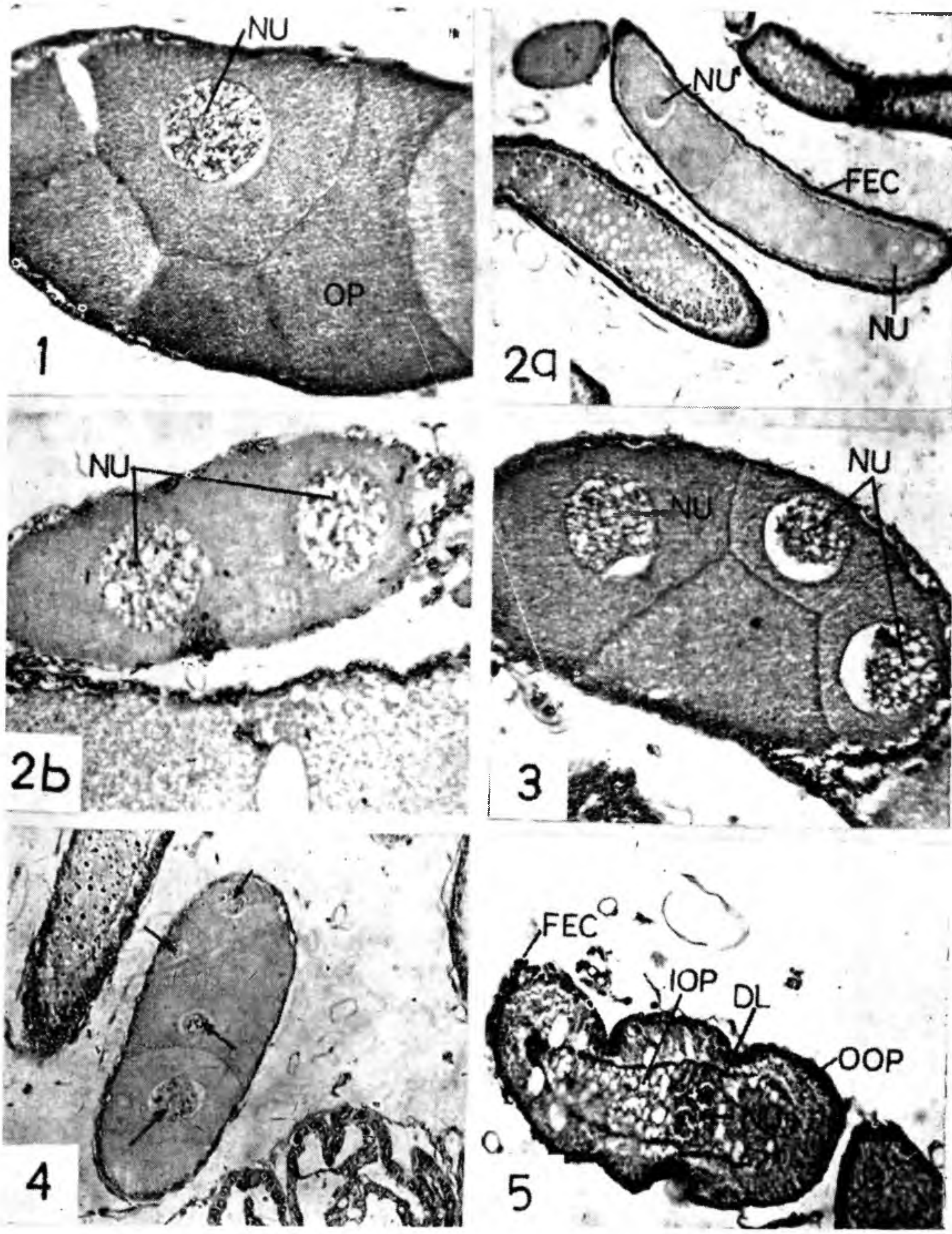
10 to 12 days :

At 10 days multinucleated oocytes, their chromatin material is shrunken and shows vacuolization. In a few oocytes degenerated yolk platelets can be seen. The pycnotic follicular layer appears uneven (Fig. 4). At 12 days, the oocytes are irregular in shape, the ooplasm shows vacuolization and is divided by a differentiating layer into two portions, the inner shows vacuoles while the outer portion is very weak in construction. The differentiating layer between types of ooplasm is an abnormal feature (Fig. 5).

14 to 16 days :

At 14 days, multinucleated oocytes are still seen, the ooplasm is prominently vacuolated and yolk formation is inhibited (Figs. 6a, b).The differentiating layer dividing the ooplasm into two portions is still evident (Fig. 6c). The follicular epithelial cells have become distinctly pycnotic and most of them have lost contact among themselves. Some of the pycnotic follicular epithelial cells become lecitholytic in nature and act as vitellophages; some of them migrate from the distal end of the oocyte into the ooplasm (Fig. 6d). At 16 days extensive damage is caused to the oocytes. The oocytes are multinucleated with severely vacuolated ooplasm and yolk formation is arrested (Fig. 7a). The tunica propria appears as a thickened layer, and the pycnotic follicular epithelial cells appear as islands of lecitholytic cells which help in the destruction and resorption of yolk (Fig. 7b). The basement membrane has lost its contact with the epithelium of the genital chamber.

The results suggests a direct toxic affect of HCH on the ovary of *P. pictus*,



EXPLANATION OF FIGURES

Photomicrographs of L S of ovary of *P. pictus* stained with haematoxylin-eosin.
Fig. 1. Oocyte showing prominent centrally located nucleus after 4 days treatment × 200. Fig. 2a. Binucleated oocytes observed after 6 days treatment × 50. 2b. Binucleated oocytes with prominent vacuolated nuclei × 200. Fig. 3. Multinucleated oocytes after 8 days treatment × 100. Fig. 4. Arrows showing multinuleated occytes after 10 days treatment × 100. Fig. 5. Irregular shape of the oocytes and arrows showing inward migration of ooplasm after 12 days treatment × 100.

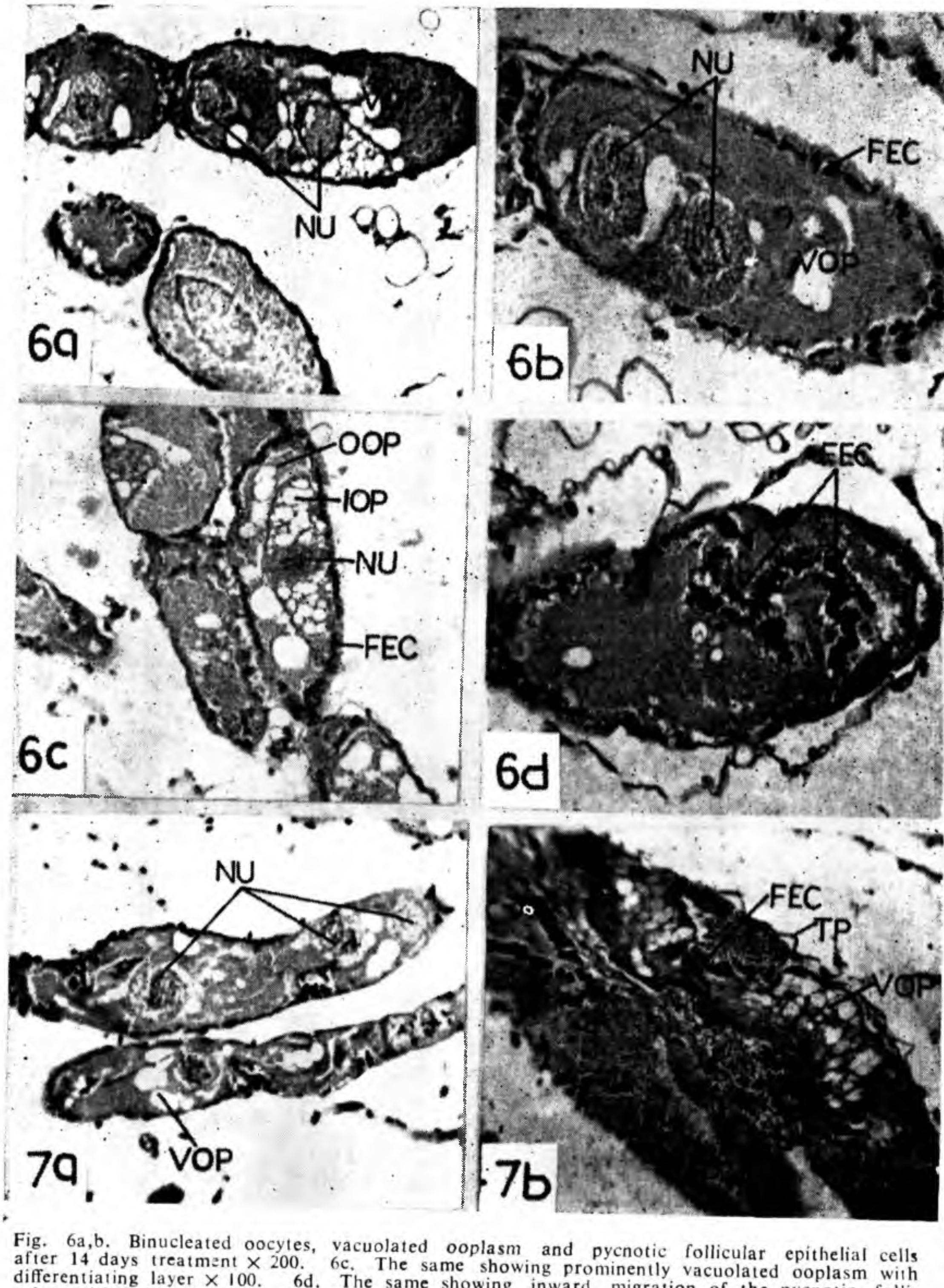


Fig. 6a,b. Binucleated oocytes, vacuolated *ooplasm* and pycnotic follicular epithelial cells after 14 days treatment × 200. 6c. The same showing prominently vacuolated ooplasm with differentiating layer × 100. 6d. The same showing inward migration of the pycnotic follicular epithelial cells × 200. Fig. 7a. Multinucleated oocytes with severely vacuolated ooplaasm after 16 days treatment × 100. 7b. The same showing pycnotic follicular epithelial cells which appear as islands of lecitholytic cells × 200.
Nu—Nucleus; OP—ooplasm; FEC—Follicular epithelial cells; TP—Tunica propria; OOP—Outer ooplasm; VOP—vacuolated aoplasm; IOP—inner ooplasm; DL—Differentiating layer.

leading to the formation of multinucleated oocytes by amitosis.

DISCUSSION

SOLIMAN and SOLIMAN showed that DDT, parathion, toxaphene and cotton dust shared in causing histopathological damages to the tissues of midgut, fat body, muscles. Malpighian tubules and CNS of *Prodenia litura*. Similarly SOLIMAN *et al.* (1971) studied tae effect of DDT, malathion and sevin on the larval tissues of Diptera. They concluded that these poisons arecapable of causing death of the maggots upon entering into their tissues in adequate amounts.

The present study in *P. pictus* shows that the effect of HCH, an organochlorine compound are quite severe over a period of 16 days. The formation of multinucleated oocytes, vacuolization of the ooplasm as well as division of the ooplasm into two portions by a differentiing layer are the abnormal features observed. Vitellogenesis is arrested in most of the oocytes and the yolk platelets present perior to the treatment become disintegrated.

It can be concluded that multincleated condition of the oocytes was due to amitotic division of the oocyte nucleus suggests that HCH not only makes the haemocytes and adipose tissue hyperactive and causes cellular deformations (unpublished observations) but also regulates the amitotic division of the oocyte nucleus causing resorption.

The organo-chlorine appears to make the tissue hyperactive and probably there is a stress which brings about cellular deformations.

Acknowledgements: The author is indebted to Professor R. S. SAINI for guidance and encouragement. The award of S R F by the Council of Scientific and Industrial Research, New Delhi is also acknowledged.

REFERENCES

CHADBOURNE, D. S. & C. F. RAINWATER (1953) Histological effects of calcium arsenate, DDT and dieldrin on the larval tissues of bollworm. *J. econ. Ent.*, **46**, 44—48.

EL-DEEB, A. L. & M. ZEID (1961) Histopathological studies on the various tissues of larvae of pink boll-worm. *J. agric. Res.*, **9**, 55—90.

FARBER, E. (1980) The genesis of cancer with chemicals. *Arch. Pathol. Lab. Med.*, **104**(10), 499—502.

NAGASAKI, S., S. TOMII, T. MEGA, M. MARUGAMI, & N. ITO (1971) Development of hepatomas in mice treated with benzene hexachloride. *Gann*, **62**, 431.

SALKELD, E. H. (1950) Changes in the histology of honey bee ventriculus associated with the ingestion of certain insecticides. *Nature*, **166**, 608.

SOLIMAN, S. A. & A. A. SOLIMAN (1958) Histopathological destruction caused to the cotton leafworm *Prodenia litura* F. by some newer insecticides. *Bull. Soc. ent. Egypte*, **42**, 199-228.

SOLIMAN, S. A., H. A. ABDEL-RAHMAN & M. M. ABDEL-DADER (1971) Histological effects of certain insecticides on the larva of *Drosophila melanogaster*. *Bull. ent. Soc. Egypt. Econ. Ser.*, **5**, 171—180.

WOKE, P. A. (1940) Effects of some injected insecticides on the midgut wall of the southern army worm larvae, *Prodenia eridania*. *J. agric. Res.*, **61**, 321—330.

Entomon, 1987, *Vol.* **12**, *No.* 3, *pp* 247 *to* 250

POST-EMBRYONIC DEVELOPMENT OF THE OVARY IN THE THRIPS, *ELAPHROTHRIPS GREENI* (BENGALL) (THYSANOPTERA : PHLAEOTHRIPIDAE)

P. S. WATANE & V. K. THAKARE

Department of Zoology, Nagpur University Campus, Nagpur, India 440 010

(Received 12 May 1986)

In the thrips *Elaphrothrips greeni*, in larva-I, ovary rudiments consist of terminal filament, germarium and young primary oocytes. In larva II prefollicular nuclei, primary oocyte and vitellarium begin to differentiate. In prepupa ovary rudiment divides and leads to the organization of four individual ovarioles. In pupa-I vitellarium is well-differentiated and oocytes are arranged in linear fashian. The follicular epithelium, inter-follicular tissue and pedicel become distinct. In pupa-II, four ovarioles of each ovary rudiment are well differentiated representing pancistic type of ovary

(Key words : post-embryonic ovarian development, thrips, *Elaphrothrips greeni)*

INTRODUCTION

Though several workers have described the histomorphology of internal reproductive organs of different species of thrips, little is known regarding the morphogenesis of female reproductive system (HEMING, 1970; & HAGA, 1975). Therefore in this paper, the development of ovary during post-embryonic development has been described in the thrips, *Elaphrothrips greeni*.

MATERIAL AND METHODS

Rearing

The thrips were collected from the local forest of Futala in the vicinity of Nagpur, on the fungus infected dry leaves of *Butea monosperma* plants, and the adult males and females were held together in the laboratory in plastic bowls containing fungus infected dry leaves of *Butea monosperma;* the bowls were covered with muslin cloth and kept at room temperature 27 ± 3°C. Humidity was maintained in the bowls by keeping soaked filter paper at the bottom. After egg laying, the newly hatched larvae were fed on the fungus coated dry leaves.

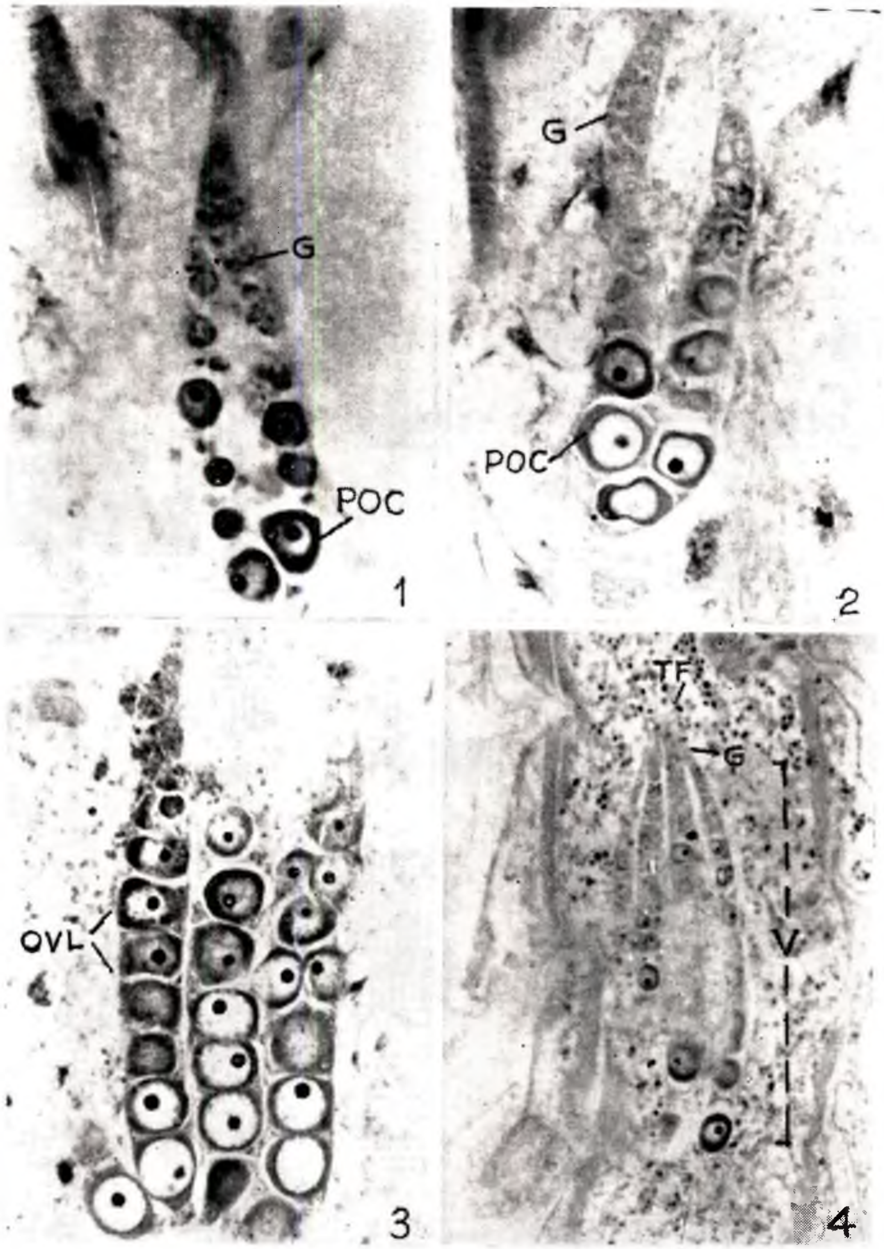
Various larval and pupal stages were collected from the rearing bowls and were fixed in Bouin's fluid. The larvae and pupae were pierced with fine needles on the thorax to facilitate penetration of the fixative. The fixed tissue was dehydrated in alcohol series, cleared in clove oil and embedded in paraffin wax. The sections of the wax embedded tissue were cut at 5 μm and stained with Heidenhain's iron-haematoxylin and Mallory's triple (HUMASON, 1972) stain.

OBSERVATIONS

Histology

Post-embryonic development of the ovary

Larva-I: In this stage, the ovary consists of a loose mass of tissue lying in the lateral side of the alimentary canal in the fifth and sixth segments of the abdomen. The terminal filament and germarium are well differentiated. The germarium contains two kinds of cells which can be differentiated as large young primary oocytes with distinct nuclei and



EXPLANATION OF FIGURES

Fig. 1. Horizontal longitudinal section (HLS) passing through the ovary rudiment of larva-II. G- germarium, POC- primary oocyte. Iron haematoxylin (IH) × 400; 2. HLS passing through ovary rudiment, of prepupa shows dividing ovary rndiment, G- germarium, POC- primary oocyte. IH × 300. 3. HLS passing through ovary rudiment of pupa-I showing ovarioles (OVL). IH × 256. 4. HLS passing through ovary rudiment of pupa-II showing four separate ovarioles, containing developing oocytes. Note the TF- terminal filament, G-germarium and V- vite llarium. IH × 160.

small indistinct prefollicular cells with prominent nuclei.

Larva-II (Fig. 1): The ovary rudiments increase in size in this stage and are surrounded by connective tissue. The vitellarium begins to differentiate. The primary oocyte has densely stained nuclei, nucleoli and granular cytoplasm. The development of follicular cells is discernible.

Prepupa (Fig. 2): In the prepupal stage, each ovary rudiment divides into four individual ovarioles. The terminal filaments develop as apical process of the ovarioles. The germarium is well-differentiated and filled with oogonia and prefollicular nuclei. In the vitellarium the posteriormost oocytes increase in size, each oocyte contains centrally placed nucleus with well stained nucleous and granular cytoplasm.

Pupa-I (Fig. 3): In pupa-I the ovarioles separated from each other and the vitellarium in each ovariole is well-differentiated. The oocytes in the vitellarium are arranged in a linear fashion. The nuclei of the oocytes increase in size and become the germinal vesicle. The prefollicular cells are loosely located among and around the oocytes, forming the interfollicular tissue and the epithelium respectively. The pedicels become distinct.

Pupa-II (Fig. 4): The four ovarioles of each ovary rudiment present panoistic type of ovary. Each ovariole exhibits four divisions distinctly; the terminal filament, the germarium, the vitellarium and the pedicel. The vitellarium bears a string of oocytes arranged in a linear fashion and the posteriormost oocyte is the largest one. The follicular cells are distinct and form the follicular epithelium around the oocytes.

DISCUSSION

During the post-embryonic development of *Elaphrothrips greeni* the primary oocytes in the ovorian rudiments are differentiated from the posteriormost oogonium in the late larva-I stage. HEMING (1970) has observed the differentiation of oocytes at the end of larva-I in *Haplothrips verbasci*. He further stated that the oocytes are surrounded by prefollicular cells in the larva-II. In *Elaphrothrips greeni* although the prefollicular cells are observed around the oocyte in larva-II, they are ill-differentiated.

The differentiation of ovarioles in the thrips generally take place slightly later as compared to most exopterygote ovarioles. In most of the exopterygotes, the ovarioles separate in the embryo or in the first or the second instar nymphs and in some endopterygote the separation occurs in the last larval or early pupal stages.

In *Elaphrothrips greeni* the differentiation of the ovarioles with distinct regions begins in pre-pupa. The process of differentiation is completed in pupa-I and separation of ovarioles occur in pupa-II. In *Haplothrips verbasci* and *Frankliniella fusca* similar pattern of post-embryonic differentiation of ovarioles has been reported by HEMING (1970). Further, these observations also conform to the earlier work by MULLER (1927) in *Parthenothrips dracaenea;* MELIS (1934) in *Liothrips olea;* BOURNIER (1956) in *Taeniothrips simplex* and *Haplothrips verbasci;* DAVIES (1961) in *Limothrips cerealium*.

In the thrips the ovarioles are of panoistic type as in other exopterygote insects with exceptions in Hemiptera and Psocoptera (IMMS, 1963), but their delayed development recalls endopterygote

morphogenesis or 'remetabolous' metamorphosis.

MELIS (1934) has reported the commencement of vitellogenesis in pre-pupal stage in *Liothrips oleae*. In *Elaphrothrips greeni* there is no evidence of commencement of vitellogenesis during larval or pupal stages; rather it occurs in adult stage; this is also reported by DAVIES (1961) and HEMING (1970).

Acknowledgements : This work has been carried out during the tenure of Faculty Improvement Programme of University Grants Commission. Teacher fellowship to PSW is gratefully acknowledged. We are thankful to Dr. D. B. TEMBHARE and Dr. A. M. KHURAD for critical reading of the manuscript. We wish to thank Mr. C. M. SORODEY for his assistance in photography.

REFERENCES

BOURNIER, A. (1956) Contribution a l'etude de parthenogenese des Thysanopteres et de sa cytologie. *Arch. Zool. exp. gen.*, **93**, 135—141.

DAVIES, R. G. (1961) The post-embryonic development of the female reprodutive system in *Limothrips cerealium*. *Proc. Zool. Soc. Lond.*, **136**, 411—437.

HAGA, K. (1975) Female reproductive system of megathripin species, *Bactridothrips brevitubus*. *Bull. Sugadaris Biol. Lab.*, **7**, 13—24.

HEMING, B. S. (1970) Post-development of the female reproductive system in *Frankliniella fusca* and *Haplothrips verbasci*. *Misc. Publ. ent. Soc. Amer.*, 7(2), 197—234.

HUMASON, G. L. (1972) *Animal Tissue Techniques* (Third ed. W. H. Freeman) San Francisco, 1—641 pp.

IMMS, A. D. (1963) *A General Textbook of Entomology*, London. Revised by RICHARDS, Methuen & Co. Ltd., London.

MEDIS, A. (1934) Nuove osservazioni antomoisotologische sui diversi stati postembrionali del *Liothrips oleae* Costa. *Radia.*, **21**, 263—334.

MULLER, K. (1927) Beitrage zur Biologie, Anatomie, Histologie und inneren Metamorphosis der Thripslarven. *Zeitschr. f. Wiss. Zool.*, **130**, 251—303.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 251 *to* 254

ACID PHOSPHATASE ACTIVITY IN THE OVARY OF THE ERI SILKWORM, *PHILOSAMIA RICINI* (HUTT.) – A HISTOCHEMICAL STUDY

H. K. HURKADLI[1], M. A. HOOLI & V. B. NADKARNI

Department of Zoology, Karnatak University, Dharwad, India 580 003

(Received 20 November 1985)

In the present study acid phosphatase activity has been histochemically demonstrated in the ovary of larva, pupa and adult eri silkworm, *Philosamia ricini*. Acid phosphatase activity has been detected in the cytoplasm of lamellar epithelial cells, matrix cells of the ovarian cap of the larval and pupal ovary, in the precursor cells of the oocyte, nurse cells and follicle epithelial cells in the germarium of larva, pupa and adult and in the cytoplasm of nurse cells, follicle epithelial cells, peripheral region of the oocyte of the previtellogenic and vitellogenic follicles of pupa and adult. This enzyme activity was also detected in the intermediate cells surrounding the previtellogenic and vitellogenic follicles and in the degenerating follicle epithelial cells and nurse cells

(*Key words:* acid phosphatase, ovary, vitellogenesis, *Philosamia ricini*)

INTRODUCTION

Acid phosphatase plays an important role in the biological phenomenon such as development, growth and maturation as well as histolysis during which high energy is required (GILBERT & HUDLESTON, 1965). Tissues having energy requirements need a readily available source of phosphate which is provided by acid phosphatase (BLUM, 1970). Studies on the distribution of acid phosphatase activity in the ovaries of insects are limited to a few species (STAY, 1959; CONE & ESCHENBERG, 1966; SAWIKI & MAC INTYRE, 1977). The present histochemical study reports the distribution of acid phospoatase activity in the ovary of larva, pupa and adult *P. ricini*.

MATERIALS AND METHODS

Eri silkworms, reared in the laboratory, were used in the present work. Bouin's fixed tissues were processed in usual manner 5 μm sections were cut and stained with haematoxylin and eosin for histological studies. The fresh frozen sections of the ovaries of IV and V instar larva, pupa and the adult were fixed in cold acetone, incubated at 37°C in freshly prepared incubation medium for two hours and the sections were washed in running water and mounted in glycerol jelly. Napthol AS-TR phosphate method of BURSTONE (1962, cited in PEARSE, 1968) was followed with AS-TR phosphate as the substrate and Fast red TR as azo-dye. The sections incubated in the medium lacking the subtrate served as controls.

[1]Karnataka State Sericulture Development Institute, Thalaghattapura, Bangalore, India 560 062.

RESULTS

The ovary of IV and V instar larva consists of ovarian cap, a layer of lamellar epithelial cells and fibrous matrix containing tabular ovarioles inside which are found precursors of oocytes, nurse cells and follicle epithelial cells (Fig. 1). The definite ovarian follicles consisting of oocyte-nurse cell complex surrounded by follicle epithelial cells appear in the ovarioles from 4th day of

pupation upto 9th day and such follicles are surrounded by intermediate cells. The follicles begin to increase in size and the follicle epithelial cells completely surround the oocyte-nurse cells complex in the ovarioles of 10th-12th day pupa and the intermediate cells at this stage are confined around the interfollicle stalk between the successive follicles. The ovarioles of adults consist of precursors of oocyte, nurse cells and follicle epithelial cells in the germarium, previtellogenic and vitellogenic follicles in the proximal and middle region of the ovarioles respectively and the mature eggs in the distal part of the ovarioles.

Acid phosphatase activity in the ovarian cells was indicated by AS-TR positive red deposits in the form of granules or needle like crystals or both. Acid phosphatase activity, in the form of large number of granules and a few elongate needle-like crystals, was observed in the cytoplasm of lamellar and matrix cells of the ovarian cap and in the cytoplasm of precursor cells in the germarium of IV and V instar larva and pupa. The enzyme activity was not observed in the nuclei of these cells (Fig. 2). The enzyme activity was also observed in the precursor cells of oocytes, nurse cells and follicle epithelial cells in the germarium of adults. However, it was not possible to detect the enzyme activity in the acellular membrane covering the ovarian cap, tunica propria, ovariolar sheath and sheath cells of the ovarioles.

Acid phosphatase activity, in the form of fine granules, was observed in the cytoplasm of follicle epithelial cells, nurse cells and in the peripheral region of the ooplasm of the oocyte in the previtellogenic and vitellogenic follicles of pupa and adult. The intermediate cells around the previtellogenic and vitellogenic follicles also showed acid phosphatase activity (Fig. 3). There was a slight increase in the enzyme activity of the dwindling nurse cells and the follicle epithelial cells after the formation of chorion around the mature follicles (Fig. 4).

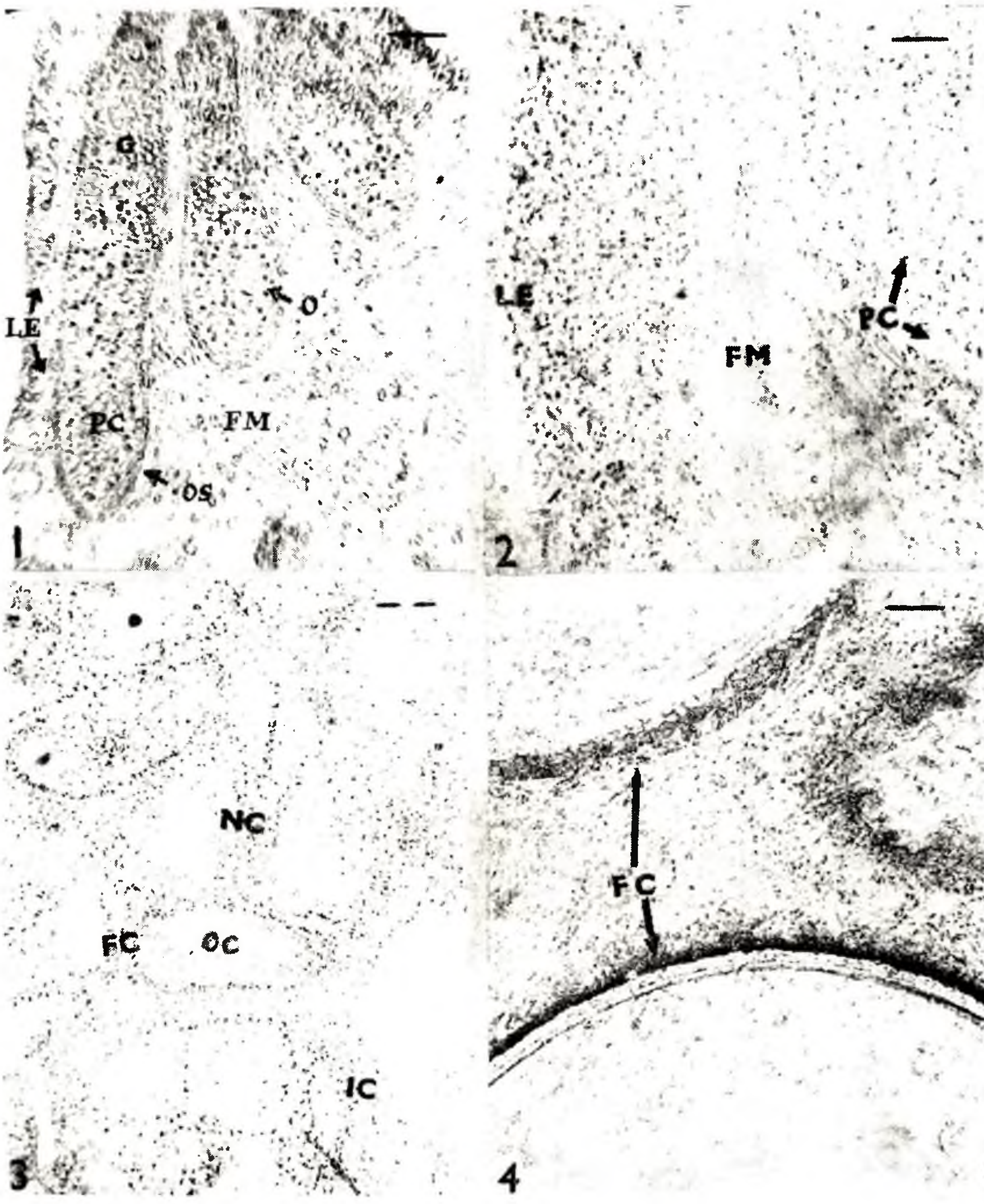
The sections incubated in the medium lacking the substrate did not show any reaction.

DISCUSSION

Acid phosphatase activity has been histochemically demonstrated in the cytoplasm and nuclei of the larval ovary in the blow fly, *Phormia regina* (STAY, 1959); however, it has not been specifically stated that which of the tissues or cells of the ovary showed acid phosphatase activity. Acid phosphatase activity has been histochemically demonstrated in the trophic core, nurse cells, follicle epithelial cells and the oocyte in the telotrophic ovary of *Gerris remigis* (CONE & ESCHENBERG, 1966), and in the nurse cells and follicle epithelial cells in the polytrophic ovary of *Drosophila melanogaster* (SAWIKI & MAC INTYRE, 1977) In the present study acid phosphatase activity has been histochemically detected in the cytoplasm of lamellar epithelial cells and matrix cells of the ovarian cap of the larval and pupal polytrophic ovary, in the cytoplasm of

ABREVIATIONS

FC—Follicle epithelial cells, FM—Fibrous matrix cells, IC—Intermediate cells, LE—Lamellar epithelium, NC—Nurse cells, O—Ovariolar sheath, PC—Precursor cells. Scale line in the microphotographs indicate 40 μm.



EXPLANATION OF FIGURES

Fig. 1. L. S. of Bouin's fixed ovary of the IV instar larva of *P. ricini* showing lamellar epithelium, fibrous matrix and the tubular ovarioles showing ovariolar sheath an precursor cells. Fig 2. Fresh frozen section of the ovary of IV instar larva showing acid phosphatase activity in the form of granules in the lamellar epithelium, fibrous matrix cells and in precursor cells in the germarium. Fig. 3. Fresh frozen section of the ovary of pupa showing acid phosphatase activity in the follicle epithelial cells, nurse cells, peripheral region of the oocyte and in intermediate cells. Fig. 4. Fresh frozen section of the mature egg shwing increased acid phosphatase activity in the degenerating follicle epithelial cells in the ovary of adult *P. ricini*.

precursor cells of oocyte, nurse cells, follicle epithelial cells in the germarium of IV and V instar larva, pupa and adult and in the cytoplasm of nurse cells, follicle epithelial cells and the peripheral region of the cytoplasm of previtellogenic and vitellogenic follicles of pupa and adult. Acid phosphatase activity was also observed in the intermediate cells surrounding the previtellogenic and vitellogenic follicles of pupa and adult. However, the enzyme activity was not observed in the nucleus of any cells in the ovary. The reaction observed in the nucleus of the ovarian cells of *P. regina* might be due to the non-specific reaction. Since phosphatases have been implicated in the intermediary metabolism and in the transfer of metabolites from the intra to the extracellular fluid and vice-versa (FRUTON & SIMMONDS, 1961) and in the autolysis of the tissues (DUVE, 1959; CONE & ESCHENBERG, 1966) acid phosphatase could play important role in insect ovary.

Acknowledgements: We thank UGC, New Delhi for awarding a fellowship to HKH and to WHO for the free gift of fine chemicals.

REFERENCES

BLUM, M. A. (1970) Invertebrate testes, 393-431, *in: The Testis*, Vol. II (Eds. A. D. JOHNSON, GOMES W. R. & N. L. VANDEMARK). Academic press.

CONE, M. V. & K. M. ESCHENBERG (1966) Histochemical localization of acid phosphatase in the ovary of *Gerris remiges* Say (Hemiptera). *J. exp. Zool.*, **161**, 337—352.

DUVE DE. C. (1959) Lysosomes, a new group of cytoplasmic particles, 128—159, *in; Subcellular Partticles* (Ed. T. Hayashi) Ronald.

FRUTON, J. S. & S. SIMMOND (1961) *General Biochemistry* (2nd ed.) John Wiley & Sons, 584 pp.

GILBERT, L. I. & C. J. HUDDLESTON (1965) Testicular acid phosphate in giant silk moth, *Samia cynthia*. *J. Insect. Physiol.*, **11**, 177—184.

PEARSE, A. G. E. (1968) *Histochemistry Theortical and Applied*. Vol. I, Churchill and Livingston Ltd.

SAWIKI, J. A. & R. J. MACINTYRE (1977) Synthesis of ovarian acid phosphatase-1 in *Drosophila melanogaster*. *Dev. Biol.*, **60**(1), 1—13.

STAY, B. (1959) Histochemical studies on the blowfly, *Phormia regina* (Meigen). II. Distribution of phosphatases, dehydrogenases and cytochrome oxidase during larval and pupal stages. *J. Morphol.*, **105**, 457—494.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 255 *to* 260

B-CHROMOSOME SYSTEM IN A WINGLASS GRASSHOPPER, *ORTHOCRIS* SP. BOL. (INSECTA : ACRIDIDAE)

K. UMADENI & N. V. ASWATHANARAYANA

Department of Zoology, University of Mysore, Manasa Gangotri, Mysore India 570 006

(Received 7 March 1986)

The karyotype, constitutive heterochromatin, and meiosis of *Orthocris* sp. are described for the first time. The male diploid number is 19 (18 + *XO*) with all acrocentric chromosomes. The behaviour of *B*-chromosome during meiosis is discussed

(Key words: orthocris sp., acridid, karyotype, *B*-chromosome, meiossis, constitutive heterochromatin)

INTRODUCTION

All natural populations are endowed with some kind of variations of varying degrees. These variations may be at the molecular level or chromosomal level. Chromosomal changes are either structural or numerical. These variations are very much helpful in understanding the chromosomal evolution. Basic characters like karyotypic details and the distribution of constitutive heterochromatin are not known in many of the species to explore the cryptic karyotypic differences and to know the evolutionary trends. Orthoptera is an exploited group for karyotypic studies. Extensive research work has been done on a number of acridid species from different parts of the world. In India, though the work was started very early by ASANA (1928), the chromosomal data of some species are still inadequate or completely wanting. One such is *Orthocris* sp., in which only the chromosome number is known (RAO, 1933). Further studies on this species has not been done to-date. In view of this a systematic chromosome study was undertaken. In this article, the details of the karyotype, distribution of constitutive heterochromatin and the behaviour of *B*-chromosome during meiosis are described.

MATERIALS AND METHODS

A total of 56 individuals of the shorthorned grasshopper, *Orthocris* sp. were collected from three areas viz., Manasa Gangotri, Mysore (20 males and 8 females), Hebbal, Bangalore (6 males and 6 females) and Harur, Tamil Nadu (12 males and 4 females) for chromosomal analysis. Testes and hepatic caecae were used after 3 hours of 0.1 ml of 0.025% colchicine treatment and processed for chromosomal preparations by haematoxylin squash and air-dry-Giemsa methods. C-banding was done using the modified technique of SHAW *et al.* (1976).

OBSERVATIONS

The diploid chromosome number in males is 19 (18 + *XO*) and all the chromosomes are acrocentric but the minute second arm appear inconsistently to mislead them as telocentric (Fig. 1). There are two pairs of long chromosomes and the remaining are in a graded series. The *X*-chromosome is the longest of the complement.

Fig. 1. Karyotype of spermatogonial metaphase of normal individual.

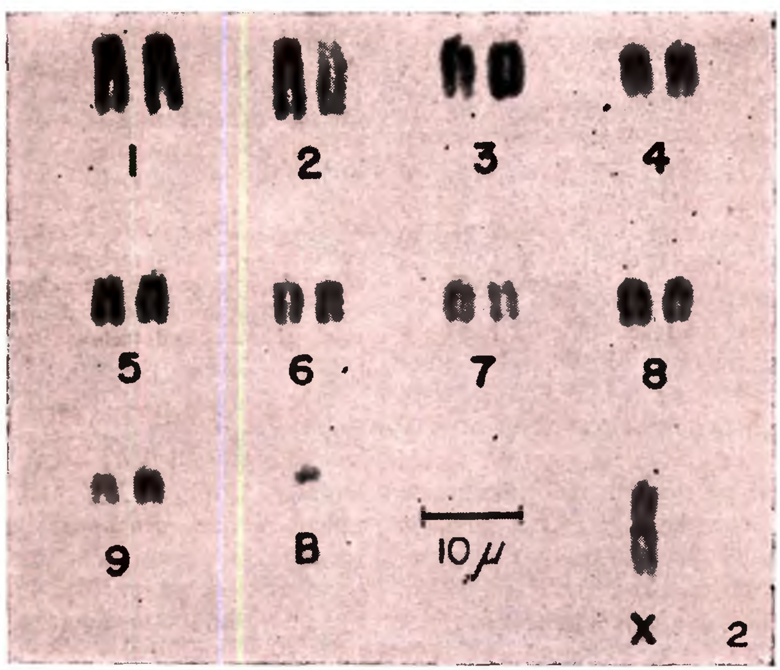


Fig. 2. Karyotype of spermatogonial metaphase with one *B*-chromosome.

Out of 20 males, one *B*-chromosome was present in two individuals of Manasa Gangotri and in one, out of 12 individuals in Harur population (Fig. 2). It is the smallest of the complement. No size variation of *B*-chromosome was observed in both populations. The morphometric details of the karyotype with and without *B*-chromosomes are compared (Table 1)

TABLE 1

Chromosome number	L^R of the individuals with *B*-	L^R of the individuals without *B*-
1	126.79	129 11
2	121.01	123.76
3	100.07	103.27
4	90.16	97.97
5	87.00	91.61
6	83.41	87.02
7	78.37	82.40
8	74 92	74.67
9	69.71	66.07
x	144.28	144.06
B	37.74	—

In C-banding, all the autosomes and the *X*-chromosome exhibit the C-bands only in the pericentric regions while the entire *B*-chromosome stains completely dark showing its heterochromatic nature (Fig. 3).

In leptotene, the *B*-chromosome appears as a positively heteropycnotic body in the vicinity of the sex vescicle. (Fig. 4). By the time, the cell reaches late diakinesis, the *X*-chromosome and the *B*-chromosome become distinct (Fig. 5). The *X*-chromosome is negatively heteropycnotic which character continues till anaphase I. The staining of the *B*-chromosome is similar to the bivalents but it does not associate with the other chromosomes. The segregation of *B*-chromosome is random resulting in two types

Fig. 3. C-banded metaphase with B. chromosome. All the chromosomes exhibit centromeric bands. The *B*- chromosome is darkly stained.

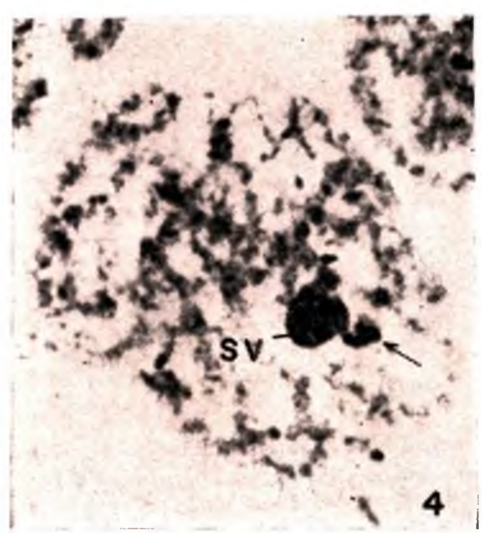


Fig. 4. Leptotene *B*-chromosome mass is closely associated with the sex vascicle.

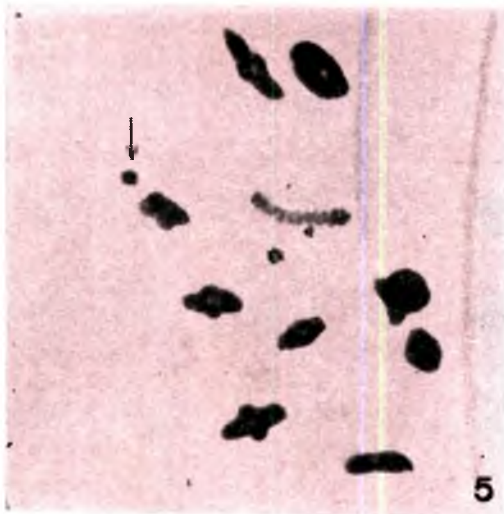


Fig. 5. Diakinesis – Note the negatively hetero-pycnotic X-chromosome.

Fig. 7. Metaphase II-Nine autosomes with the X-chromosome and B-chromosome.

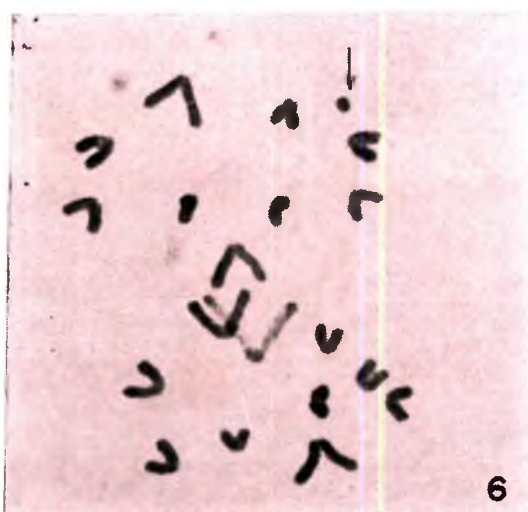


Fig. 6. Anaphase I – X and B chromosomes passing to the opposite poles.

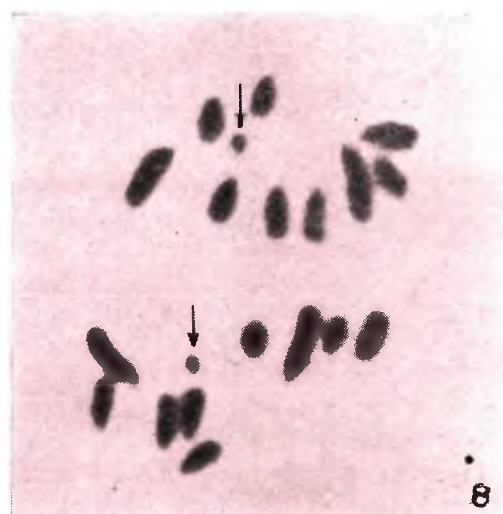


Fig. 8. Anaphase II- Nine autosomes with the B-chromosome in each polar complement (Arrow indicates B-chromosome).

of cells, one with *B*-chromosome and the other without it (Fig. 6). In metaphase II (with *B*-ehromosome) the *B*-chromosome retains its individuality (Fig. 7) and divides equationally in the second division (Fig. 8).

The chiasma frequency of the individuals with *B*-chromosome when comparad with the normal individuals, there was no significant increase in chiasma frequency.

DISCUSSION

The only report on the chromosomes of the wingless grasshopper, *Orthocris* sp. is of Rao (1933), who described 19 ($18A+XO$) acrocentric chromosomes in males. The present study confirms these features. The karyotype has two pairs of long ceromosomes and the remaining ones are in a graded series while the *X*-chromosome is the longest element. The metrical data of the chromosome complement with and without *B*-chromosome are presanted (Table 1) which clearly show the differences in the L^R values of the autosomes. But the L^R of *X*-chromosome is almost the same in all the individuals i.e., 37.74.

Mitotically stable, single *X*-chromosome are reported in many species of acridide (White, 1949; Ray-Chaudhary & Manna 1951; John & Hewitt, 1965; Kayano, 1971; Gururaj & Rajasekarasetty, 1971). The occurrence of *B*-chromosomes, nature of constitutive heterochromatin is presented in *Orthocris* sp. for the first time. The *B*-chromosome in the Mysore and Harur populations are mitotically stable. It is observed that, the *B*-chromosmes from both the populations show similarity in morphology and behaviour during meiosis. Generally, *B*-chromosomes arise from the members of the regular karyotype. It might have originated from the autosomes as evidenced by the metrical values (Table 1). Though *B*-chromosome was reported in 1000 plant speciss and about 260 animal species, there is no example which records the origin and evolution of a particular *B*-chromosome (Jones & Rees, 1982).

The presence or absence of *B*-chromosome does not normally affect the phenotypic changes in a noticeable way in the individual. However, it can bring about a variety of effects like, fecundity and viability of the organisms (White, 1973), quantitative effects on chromosome pairing, development rate and fertility (Gibson & Hawitt, 1972) and the significant increase in the chiasma frequency as in *Myrmeleotettix maculatus* (John & Hewitt, 1965) and *Acrotylus humbertianus* (Gururaj & Rajasekarasetty, 1971). In the present study, we did not observe any change in the phenotype and also significant changes as in the case of *Podisma pedistris* (Hewitt, 1975). These instances reveal that the effect of the *B*-chromosome is not expressive as in the other species. Further existence of a *B*-chromosome may be just a "floating type" which might be fixed in the population if it is advantageous or it will be eliminated.

Acknowledgement: Theauthors are highly thankful to Prof. N. B. K. Krishnamurthy, Head Department of Zoology, University of Mysore, Mysore. for encouragement and facilities. This work is supporied by a research grant by the UGC, New Delhi to one of us (NVA).

REFERENCES

Edward Gurkraj, M. & M. R. Rajasekarasetty (1971) Impact of *B*-chromosome polymorphism on the endophenotype of *Acrotylus humbertionus* (Acrididae : Orthoptera). *J. Cytol & Genet. Congr. Suppl*, 151—158.

GIBTON, I. & G. M. HEWITT (1972) Interpopulation variation in the satellite DNA from grasshopper with *B*-chromosome. *Chromosoma*, **38**, 121—138.

HEWITT, G. M. (1975) A sex chromosome hybrid zone in the grasshopper *Podisma pedistris* (Orthoptera : Acrideidea). *Heredity*, **35**, 375—387.

JONES, R. N. & H. REES (1982) *B-chromosomes*, Academic Press, London.

JOHN, B. & G. M. HEWITT (1965) The *B*-chromosome system of *Myrmeleotettix maculatus*. The mechanics. *Chromosoma*, **16**, 548.

KAYANO, H (1971) Accumulation of B-chromosomes in the germ line of *Locusta migratoria*. *Heredity*, **27**, Part 1, 119—123.

RAMACHANDRA RAO, T. (1933) Chromosomal aberrations occurring in unirradiated grasshoppers. *J. Mysore Univ.*, VII, No. 1 pp.

RAYCHAUDHARY, S. P. & G. K. MANNA (1951) Chromosome evolution in wild populations of Acrididae. I. On the occurrence of supernumerary chromosome in *Aiolopus species*. *Proc. Indian Acad of Sci.*, **34**, pp.

SHAW, D. D., G. C. WEBB & P. WILKINSON (1976) Population cytogenetics of the genus *Caladia* (Orthoptera : Acrididae). II. Variation in the pattern of C-banding. *Choromosome*, **56**, 169—190.

WHITE, M. J. D. (1949) A cytological survey of wild populations of *Trimerotropis* and *Circotettix* (Orthoptera : Acrididae). I. The chromosomes of 12 species. *Genetics*, **34**, 537—556.

WHITE, M. J. D. (1973) *Animal Cytology and Evolution*. 3rd Edn., Cambridge University Press.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 261 *to* 265

EFFECTS OF HYDROPRENE AND METHOPRENE ON THE GROWTH AND DIFFERENTIATION OF TESTIS OF RICE STEM BORER *SCIRPOPHAGA INCERTULAS* WLK. (LEPIDOPTERA, PYRALIDAE) FOLLOWING POST-DIAPAUSE PUPAL TREATMENTS

N. ROYCHOUDHURY & S. CHAKRAVORTY

Entomology Laboratory, Department of Zoology, University of Kalyani, Kalyani India 741 235

(Received 7 March 1986)

The post-diapause pupae of *Scirpophaga incertulas* Walk., following hydroprene and methoprene treatments, are subjected to severe derangemants in growth and differentitation of testes. In most of the defective pupae the testes have not grown to the extent of normal status. Either the two developmental testis-sacs remain loosely fused or, in rare cases, remain separate. The histology of testis of defective pupa and adultoid is also much deranged showing fewer cysts and smaller malformed sperm bundles.

(*Key words:* hydroprene, methoprene, testis, growth, differentiation, *Scirpophaga incertulas*)

INTRODUCTION

Influenee of juvenile hormone (JH) on the development of testis and on the process of spermatogenesis in insects has been emphasized by several workers TAKEUCHI, 1969; YAGI & KURAMOCHI 1976; AMBIKA & PRABHU, 1978; LEVIATAN & FRIEDLANDER, 1979). Among the lepidopteran insects, juvenoids inhibit the process of spermatogenesis and produce defective sperms when applied to the pupal stage (DEB & CHAKRAVORTY, 1981 in *Corcyra cephalonica;* GELBIC & METWALLY, 1981 in *Spodoptera littoralis)*. The present communication is the first attempt to screen the effects of hydroprene and methoprene on the growth and differntiation of testis of *Scirpophaga incertulas* Wlk. following post-diapause pupal treatment.

MATERIALS AND METHODS

Experimental insect

The post-diapause partly exarate pupae (ISAAC & VENKATRAMAN, 1941) of *S. incertulas* obtained from the laboratory stock culture of diapausing larvae which were collected by incising the tillers of rice stubbles in the month of December when the larvae had just entered diapause. The larvae, each lodged inside a piece of small glass tube 5 cm long, 5 mm bore) with moist cotton plugging at both ends and wrapped with black paper, were reared inside a chamber having temperature 23° ± 1°C, light-dark cycle 11—13 hours and relative humidity 70—80% (ROYCHOUDHURY *et al.*, 1985). The treated and control pupae were lodged similarly and reared in the chamber at 29° ± 1°C and light-dark cycle 14-10 hours and relative humiditity 80—90% (ROYCHOUDHURY & CHAKRAVORTY, 1985).

Application of chemicals and evaluation of the effects

Juvenoids hydroprene or ZR-512 (Zoecon, ethyl 3, 7, 11-trimethyl-2, 4-dodecadienoate)

and methoprene or ZR-515 (Zoecon, isopropyl 11-methoxy-3,7, 11-trimethyldodeca-2, 4-dienoate) were applied topically in acetone solution on 0-24 h old pupae at the rates of 100 μg, 10μ and 1 μg per individual. Each individual received 1 μl soultion containing the required amount of the chemical and 1 μl of pure acetone per individual served as control treatment. Since 1 μg of any of the juvenoids could not induce any morphogenetic change in the internal tissues, this dose was disregarded in the present investigation.

The effects of juvenoids were evaluated in 12-day-old defective pupae (non-emerged adultoids) or in 0-24 h old adultoids emerged. Some pupea (control) just after acetone treatment were sacrificed for studying the initial state of testicular picture. Remaining pupae (control) were allowed to develop and emerge as normal adults which were sacrificed at 12-day old corresponding to that of the non-emerged adultoids of treated series. The male reproductive system was dissected in insect Ringer solution. The tissues were fixed in Bouin-Duboscq (alcoholic Bouin's fluid) for 48 h and stained in Mason's trichrome for histological studies.

RESULTS

Normal development:

The testes of *S. incertulas*, containing only some undifferentiated cell masses, spermatogonial and spermatocytic cysts, became visible as two extremely delicate sacs (testis-sac) in the early stage of ultimate larval instar, each located laterally in the 5th abdominal segment. Within 48-72 h of pupal life the two sacs became enclosed in a single sac. Within 12-24 h of pupal life spermatozoan cysts began to differentiate. Development of new spermatogonia continued upto a maximum of 72 h of pupal life, differentiation and maturation processes proceeded simultaneously within the testis.

The cysts of different stages of spermatogenesis of an unmated moth were not compactly arranged (Fig. 1). The mature sperm cyst was some what elongate. The sperm heads were elongate, slender and formed a bundle (Fig. 2).

Effects of juvenoid application:

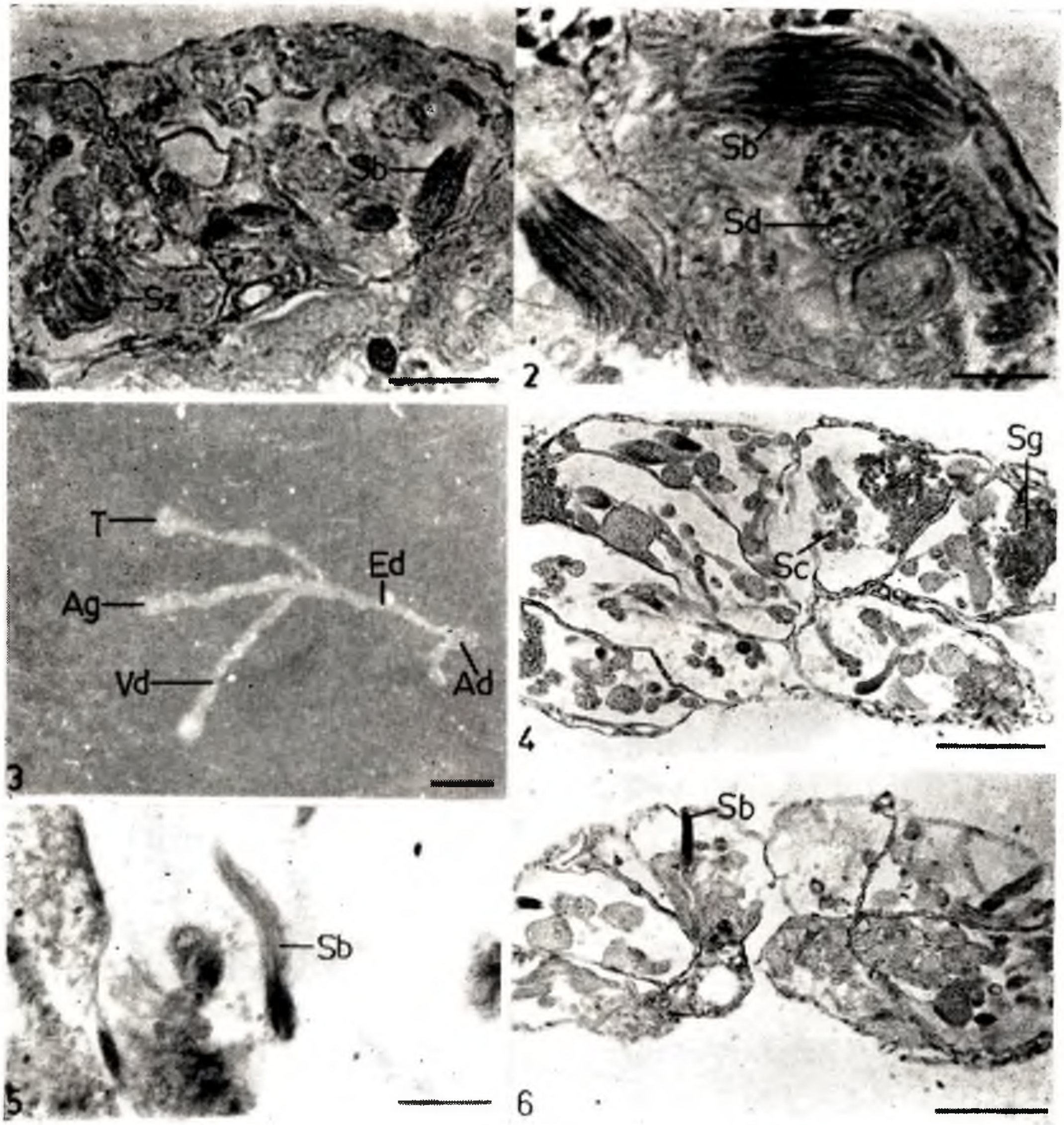
Anatomical abnormalities: Application of hydroprene and methoprene on the post-diapause pupae induced the production of good percentage of defective pupae (CHAKRAVORTY & ROYCHOUDHURY, 1986). In most of the defective pupae the testes could not grow to the extent of normal status. Either the two developmental testis-sacs remained loosely fused or in rare cases the two testis-sacs remained separate (Fig. 3). The size of testis was noticeably reduced and elongated antero-posteriorly.

Histological abnormalities: Both the juvenoids, when applied to the post-diapause papae, produced severe derangements in the histoarchitecture of testis. Some of the histological derangements were common to both defective pupae and adultoids and these were: the follicles contained loosely arranged cysts (Fig. 4) and smaller sperm bundles (Fig. 5).

Abnormalities, typical of defective pupae, were: the testis-sacs which became loosely fused showed ill developed scrotum or even in some cases scrotum could not be visible under light microscope (Fig. 6). The abnormality, found in some adultoids which were obtained after hydroprene treatment, was compactly arranged cyst population with a few sperm bundles.

DISCUSSION

Treatment of hydroprene and methoprene on the post-diapause pupae of *S. incertnlas* affected morphogenesis of testis throgh derangements in the anatomy and histology. According to SLAMA *et al.*



LEGENDS TO FIGURES

Fig. 1. Section of testis of a control moth. Scale bar : 50 μm. Fig. 2. Two sperm bundles in the testis of a control moth. Scale bar : 25 μm. Fig. 3. The male reproductive pupa obtained due to 100 μg of methoprene treatment. The two developmental testis-sacs could not fuse into a single sac. Scale bar : 1 mm. Fig. 4. Section of testis of an adultoid obtained due to 10 μg of hydroprene treatment. Population density of malformed cysts very much reduced. Scale bar : 50 μm. Fig. 5. Section of testis of an adultoid obtained due to 10 μg of methoprene treatment. A single reduced malformed sperm bundle. Scale bar 25μm. Fig. 6. Section of testis of a defective pupa obtained due to 100 μg of methoprene. Two developmental testis-sacs remained loosely fused and unequal. Scale bar : 50 μm. T = Testis-sac, Vd = Vas deferens, Ag = Accessory gland, Ed = Ejaculatory duct, Ad = Aedeagus, Sg = Spermatogonia, Sc = Spermatocyte, Sd = Sermatid, Sz = Spermatozoa, Sb = Sperm bundle.

(1974) and NOVAK (1975) juvenoids may affect the process of spermatogenesis in a very similar way to that found in other adult tissues during metamorphosis. The observations of RIDDIFORD (1975) on *Hyalophora cecropia* also support this view. This idea holds good in the present finding and thus explains the failure of fusion of two testis-sacs.

The reduction in the number of testicular cysts as recorded in the present investigation is similar to the obsernations of DEB & CHAKRAVORTY (1981) in *C. cephalonica* made after hydroprene treatment. The histomorphological derangements, e.g., ill developed scrotum, thin malformed testicular cyst population and reduced length of sperm bundles suggest inhibitory action of the juvenoids. Similar results have also been reported by LANDA & METWALLY (1974) in *Trogoderma granarium* and by GELBIC & METWALLY (1981) in *S. littoralis*. The possible cause of reduction in the length of sperm bundles and of the formation of round sperm bundles which have been recorded in the present investigation may be due to the inhibitation of elongation of the nucleus, during transformation of spermatid to sperm, due to high titre of juvenoid through exogenous treatment (LEVIATAN & FRIEDLANDER, 1979).

AMBIKA & PRABHU (1978) have found that JH stimulates transformation of spermatocytes into spermatids and sperms in *Dysdercus cingulatus*. According to them JH has a direct effect on spermatogenesis. SZOLLOSI (1975) has found that the effects of juvenoids on spermatogenesis are not direct and that the srerility in male is caused by the inhibition of development of imaginal spermiducts.

It has also been observed in the present work that methoprene is more effective than hydroprene in inducing reduction of the number of cysts per testis. This is possible because the kinetics of degradation and excretion of the two juvenoids are also variable, hydroprene degrades more rapidly than than methoprene (WEIRICH & WREN, 1973).

However, all these findings, indicate a sort of certain degree of male sterility induced by juvenoids following treatment in the post-diapause pupae of *S. incertulas*.

Acknowledgements: Authors are indebted to Dr. G. B. STALL, Zoecon Corporation, California USA for the generous gifts of hydroprene and methoprene. Grateful thanks are to the University of Kalyani for partial financial assistance and to the Head, Department of Zoology, University of Kalyani, for providing laboratory facilities.

REFERENCES

AMBIKA, B. & V. K. K. PRABHU (1978) Endocrine influence spermatogensis in the red cotton bug, *Dysdercus cingulatus* (Pyrrhocoridae : Heteroptera). *Entomon*, **3**, 165-175.

CHAKRAVORTY, S. & N. ROYCHOUDHURY (1986) Effects of juvenoids on morphogenesis of female reproductive system in the pupae of *Scirpophaga incertulas* (Lepidoptera, Pyralidae). *Acta ent. bohemoslov.*, **83**, 401—410.

DEB, D. C. & S. CHAKRAVORY (1981) Juvenoid-induced effects on the growth and differentiation of the testis in the rice moth, *Corcyra cephalonica. J. Insect Physiol.*, **27**, 397—402.

GELBIC, I. & M. M. METWALLY (1981) Changes in the development of male germinal cells in *Spodoptera littoralis* caused by the effects of juvenoids (Lepidoptera : Noctuidae). *Acta ent. bohemoslov.*, **78**, 10—17.

ISACC, P. V. & T. V. VENKATRAMAN (1941) A key for the identificatioon of the pupae of the known lepidopterous borer of sugar cane in India, based on morphological characteristics. *Indian J. agric. Sci.*, **11**, 804—815.

LANDA, V. & M. M. METWALLY (1974) Effects of conventional, chemosterilants and juvenile hormone analogues on spermatogenesis in *Trogodeama granarium* (Coleoptera, Dermestidae). *Acta ent. bohemoslov.*, **71**, 145—152.

LEVIATN, R. & M. FRIEDLANDER (1979) The eupyrene-apyrene dichotomous spermatogenesis of Lepidoptera : I. The relationship with post embryonic development and the role of juvenile hormone titre towards pupation. *Dev. Biol.*, **68**, 515—524.

NOVAK, V. J. A. (1975) *Insect Hormones.* Chapman and Hall (2nd Eng. Edn.).

RIDDIFORD, L. M. (1975) Juvenile hormone induced delay of metamorphosis of the viscera of the cecropia silk worm. *Biol. Bull.*, **148**, 429—439.

ROYCHOUDHURY, N. & S. CHAKAVORY (1985) Effects of hydroprene and methoprene on the developmeht and metamorphosis of rice stem borer *Scirpophaga incertulas* Wlk. (Lepidoptera : pyralidae). *Uttar Pradesh J. Zool.*, **5**, 178—184.

ROYCHOUDURY, N., M. K. GHOSH & S. CHAKRAVORTY (1985) Effect of ligature and concomitant decapitation of the diapausing larvae of two species of rice stem borers. *Zool. Anz.*, **215**, 189—194.

SLAMA, K., M. ROMANUK & F. SORM (1974) *Insect Hormones and Bioanalogues.* Springer Verlag.

SZOLLOSI, A. (1975) Imaginal differentiatian of the spermiduct in acridids : effects of juvenile hormone. *Acrida*, **4**, 205—216.

TAKEUCHI, S. (1969) Endocrinological studies on spermatogenesis in the silkworm, *Bombyx mori. Devl. Growth Differ.*, *Acrida*, **11**, 8-28.

WEIRCH, G. & J. WREN (1973) The substrate specificity of juvenile hormone esterase from *Manduca sexta* haemolymph. *Life sci.*, **13**, 213—226.

YAGI, S. & K. KURAMOCHI (1976) The role of juvenile hormone in larval duration and spermiogenesis in relation to phase variation in the tobacco cutworm, *Spodoptera litura* (Lepidoptera : Noctuidae). *Appl. ent. Zool.*, **11**, 133—138.

Entomon, 1987, *Vol.* **12**, *No.* 3, *pp.* 267 *to* 271

KARYOLOGICAL STUDIES IN FIVE SPECIES OF HORMAPHIDINE APHIDS (HOMOPTERA : APHIDIDAE)

A. R. KHUDA-BUKHSH & INDRANIL KAR

Department of Zoology, University of Kalyani, Kalyani, India 741 235

(Received 1 August 1986)

The diploid number, mitotic behaviour and morphometrical analysis of somatic chromosomes in embryos of apterous viviparous females of Hormaphidine aphids, *Ceratovacuna perglandulosa*. *Ceratovacuna silvestrii*, *Pseudoregma bambusicola*, *Paraoregma alexanderi* and *Ceratoglyphina bambusae bengalensis* have been presented. *C. silvestrii* was collected from grass and the rest from bamboo hostplants in and around Kalimpong, Distt. Darjeeling, West Bengal. All the five species had $2n = 12$ chromosomes with no apparent morphological difference in their diploid complements. An attempt has been made to evaluate their possible karyological interrelationships by morphometrical analysis.

(Key words: cytotaxonomy, bamboo aphids, Hormaphidinae)

INTRODUCTION

Out of over 750 species of aphids recorded in India (GHOSH, 1985; SARKAR & RAYCHAUDHURI, 1985), some 80 odd species have so far been cytologically investigated (KHUDA-BUKHSH, 1985; KURL, 1985). As far as the authors are aware, the Indian hormaphidine aphids, particularly those infesting bamboos and grasses, had not been cytologically studied earlier.

In the present paper, the diploid number, mitotic behaviour and morphometrical analysis of chromosomes of five species of aphids, four of them collected from the bamboo and one from grass plants, are reported.

MATERIAL AND METHODS

Young embryos squeezed from the abdomen apterous viviparous females of five species of hormaphidine aphids, *Ceratovacuna perglandulosa* BASU, GHOSH & RAYCHAUDHURI, *Ceratovacuna silvestrii* (Takahashi), *Pseudoregma bambusicola* (Takahashi), *Paraoregma alaxanderi* (Takahashi) and *Ceratoglyphina bambuse bengalensis* GHOSH, were subjected to Citrate-airdrying-Giemsa stain schedule decribed elsewhere (KHUDA-BUKHSH & PAL, 1984a, 1985) for the cytological preparations. The details of the collection data including the names and families of the host plants, the time and locality of their collection have been furnished in Table 1. The idiograms (Figs. 6–10) were constructed from the relative percentage lengths (RL) of individual pairs of individual pairs of chromosomes and the arbitrary nomenclature of chromosomes ascribed according to KHUDA-BUKHSH & PAL (1904a, 1985).

RESULTS

Mitotic behaviour:

The mitototic hehaviour of chromosomes in the five species was typical of aphids (DATTA & KHUDA-BUKHSH, 1980; KHUDA-BUKHSH & PAL, 1984 b, 1985).

Diploid chromosome number and morphametrical analysis:

The diploid metaphase complements in all the five species, viz., *Ceratovacuno perglandulosa* (Fig. 1), *C. silvestrii* (Fig. 2),

TABLE 1. List of species, their host plants and date of collection from Kalimpong, West Bengal.

Name of the species	host plants and families	date
Ceratovacuna perglandulosa Basu, Ghosh & Raychaudhuri	*Bambusa* sp. (Gramineae)	05-05-86
Ceratovacuna silvestrii (Takahashi)	Grass (Gramineae)	08-05-86
Pseudoregma bambusicola (Takahashi)	*Bambusa* sp. (Gramineae)	08-05-86
Paraoregma alexanderi (Takahashi)	*Bambusa* sp. (Gramineae)	05-05-86
Ceratoglyphina bambusae bengalensis Ghosh	*Bambusa* sp. (Gramineae)	05-05-86

Pseudoregma alexanderi (Fig. 3), ***Paraoregma bambusicola*** (Fig. 4) and ***Ceratoglyphina bambusae bengalensis*** (Fig. 5), contained 12 chromosomes measuring between 4.70 and 2.70 μm*, 4.99 and 2.61, 4.97 and 2.39, 5.06 and 2.34 and 3.33 and 1.70 respectively from the longest to the shortest ones (Table 2). The chromosomes in all the species were gradually seriated (Fig. 6-10). However, following KHUDA-BUKHSH & PAL (1984a, 1985), the chromosomes could be put into two arbitrary groups the 1st pair as 'Medium" (M) and the rest five pairs as "Short" (S) in all but *P. alexanderi* which had the 2nd pair in the "Medium" category for its R_L value lay just above the borderline of the "Short" category. The 2nd pair of chromosomes in all the species except ***P. alexanderi*** had their R_L values lying just below the borderline, which accounts for the slight difference in the chromosome formula of $n=2M+4S$ in ***P. alexanderi*** as compared to $n=1M+5S$ in the other four species (Table 2). The differences in size were 0.43, 0.68, 0.79, 0.66 and 0.51 between the 1st and 2nd pairs, 0.37, 0.44, 0.59, 0.59 and 0.27 between the 2nd and 3rd pairs, 0.33, 0.37, 0.30, 0.61, and 0.33 between the 3rd and 4th pairs, 0.47, 0.31, 0.24, 0.31 and 0.07 between the 4th and 5th pairs, and 0.40, 0.58, 0.66, 0.55 and 0.45 between the 5th and 6th pairs of chromosomes in ***C. perglandulosa, C. silvestrii, P. bambusicola, P. alexanderi and C. bambusae bengalensis*** respectively. Therefore, the maximum difference in size was noted between the 1st and 2nd pairs in all the five species while the minimum difference was noted between the 4th and 5th pairs in all but ***C. perglandulosa*** in which it was observed between the 3rd and 4th pairs of chromosomes (Table 2). Thus, minor differences in their detailed morphometrical data notwithstanding, there was a striking similarity in both diploid number and morphology of chromosomes in the five species of Hormaphidine aphids, four of which shared a common host plant ***(Bambusa*** sp.) while the other had a different but related host plant (grass).

* All measurements are in μm unless hitherwise stated.

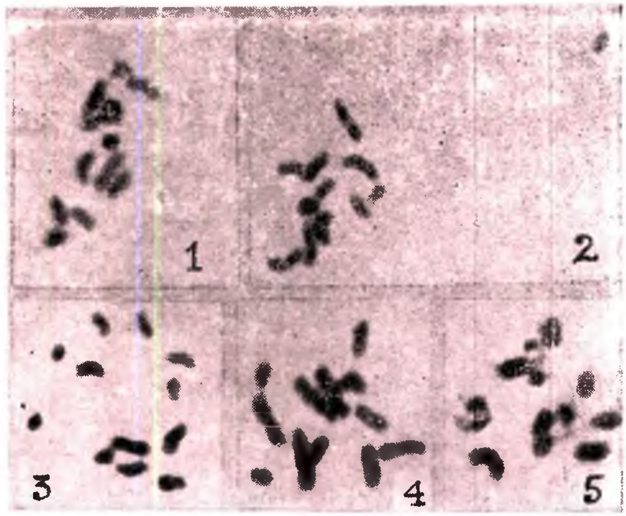
DISCUSSION

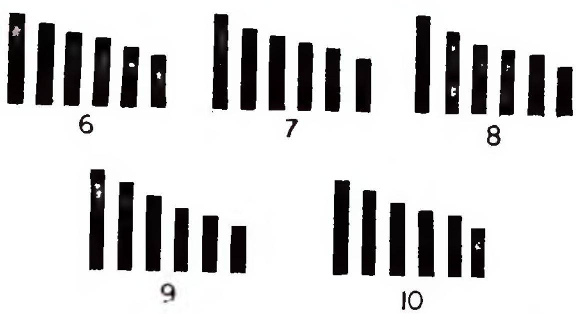
As mentioned before, Indian Hormaphidine aphids had not been cytologically investigated earlier, for which karyotypic comparison with other species could not

TABLE 2. Mean lengths and relative percentage lengths (R_L) of chromosomes expressed as haploid set in five species of the sub-family hormaphidinae.

Name of species		Serial number of chromosomes											
		1		2		3		4		5		6	
		Mean l. (μm)	R_L %	mean l. (μm)	R_L %	mean l. (μm)	R_L %	mean l. (μm)	R_L %	mean l. (μm)	R_L %	mean l. (μm)	R_L %
Ceratovacuna perglandulosa		4.78	21.13	4.27	19.19	3.90	17.53	3.57	16.05	3.10	13.93	2.70	12.14
	SE±	0.78	M	0.61	S	0.49	S	0.49	S	0.29	S	0.17	S
Ceratovacuna silvestrii		4.99	22.20	4.31	19.18	3.87	17.22	3.50	17.57	3.19	14.19	2.61	11.61
	SE±	0.18	M	0.04	S	0.15	S	0.24	S	0.26	S	0.36	S
Pseudoregma bambusicola		4.97	23.14	4.18	19.46	3.59	16.72	3.29	15 32	3.05	14.20	2.39	11.13
	SE±	0.97	M	0.76	S	0.56	S	0.43	S	0.40	S	0.23	S
Paraoregma alexanderi		5.06	23.31	4.40	20.27	3.81	17.55	3.20	14.74	2.89	13.31	2.34	10.78
	SE±	0.34	M	0.15	M	0.28	S	0.11	S	0.05	S	0.12	S
Ceratoglyphina bambusae		3.33	22.54	2.82	19.00	2.55	17.26	2.22	15.03	2.15	14.55	1.70	11.50
bengalensis	SE±	0.47	M	0.14	S	0.23	S	0.16	S	0.18	S	0.16	S

M = Medium (R_L 20—30%; S = Short (R_L 10—20%)





be made. The same diploid number of 12 chromosomes and the very similar karyotypic pattern in the five species would indicate their close cytogenetical kinship. Possibly minor structural rearrangements by way of fragmentation/fusion from a common form of aphid might have led to the karyotypic derivation of these species, most of which managed to settle on related host plants. Two congeneric species *Ceratovacuna perglandulosa* and *C. silvestrii* inhabiting bamboo and grass respectively, however, did not show glaring cyto-morphometric difference for their host plant preference.

So far 3 other species of the family Hormaphidinae have been cytologically studied from other parts of the world; *Thoracaphis* sp. from Japan had $2n=12$, *Euthoracaphis umpellulariae* from America had $2n=14$ and *Hamamelistes spinosus* from Canada had $2n=50$ chromosomes (Blackman, 1980) which would indicate that this sub-family is heterogenously constituted. From the available data, $2n = 12$ chromosomes seem to be the model number in this sub-family which can be confirmed (or refuted) after accumulation of substantial data.

Acknowledgements: The authors are indebted to Prof. G. K. MANNA for encouragements; to the Head, Department of Zoology, Kalyani University for laboratory facilities; to the CSIR for the financial support of the work; to Dr. MANOJ RANJAN GHOSH, Head, Department of Entomology, Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani and to Dr. ASHOK KUMAR SARKAR, Department of Botany, Kalyani University for identification of the aphid and plant specimens respectively.

REFERENCES

BLACKMAN, R. L. (1980) Chromosome numbers in the Aphididae and their taxonomic significance. *Systemic Ent.*, **5**, 7—25.

DATTA, S & A. R. KHUDA-BUKHSH (1980) Chromosomal study in the viviparous alatoid females of *Tinocallis kahawaluokalani* (Kirkaldy) (Homoptera: Aphiddidae). *Curr. Sci.*, **49**, 411-412.

KHUDA-BUKHSH, A. R. (1985) Trends in cytogenetical research of aphids in India. *Proc. 2nd National Symp. on "Recent Trends in Aphidological Studies"*, Modinagar, (In press).

KHUDA-BUKHSH, A. R. & N. B. PAL (1984a) Karyomorphology of five species of aphids. *Environment and Ecology*, **2**, 329—332.

KHUDA-BUKHSH, A. R. & N. B. PAL (1984b) Further cytological investigations on *Lipaphis erysimi* (Homoptera : Aphididae) : Chromosomal variations. *Proc. 4th All India Cong. Cytol. and Genet., in: Perspectives in Cytology and Genetics* (eds. G. K. MANNA & U. SINHA) **4**, 404—409.

KHUDA-BUKHSH, A. R. & N. B. PAL (1985) Cytogenetical on aphids (Homoptera : Aphididae) from India : I. Karyomorphology of eight species of *Aphis*. *Entomon*, **10**, 171—177.

KURL, S. P. (1985) Cytogenetic of aphids (Homoptera : Aphidoidea). *Proc. 2nd National Symp. on "Recent Trends in Aphidological Studies"*. Mondinagar, 13—28.

Entomon; 1987, *Vol.* **12**, *No.* 3, *pp.* 273 *to* 277

KARYOTYPIC STUDIES ON FIVE SPECIES OF APHIDS (HOMOPTERA : APHIDIDAE) FROM THE NORTH-EASTERN HIMALAYAS

A. R. KHUDA-BUKHSH & G. BASU

Department of Zoology, University of Kalyani, Kalyani, India 741 235

(Received 1 August 1986)

Karyomorphometric studies of five species of aphids, *Macrosiphum spirotibium, Macrosiphoniella matsumurana, Aulacorthum magnoliae, Melanaphis bambusae* and *Cinara tujafilina* collected from *Artemesia vulgaris* (Compositae), *Artemesia vulgaris* (Compositae), *Sechium edule* (Cucurbitaceae), *Bambusa* sp. (Gramineae) and *Thuja* sp. (Cupressaceae) respectively in and around Kalimpong, District Darjeeling, West Bengal, have been studied. All the five species had $2n = 12$ chromosomes, but they differed to some extent in their detailed karyomorphology.

(*Key words:* aphids, cytotaxonomy: North-Eastern Himalayas)

INTRODUCTION

Over 750 species of aphids have so far been taxonomically recorded in India (GHOSH, 1985; SARKAR & RAYCHAUDHURI, 1985) but cytological investigations are limited to some 80 odd species (KHUDA-BUKHSH, 1985; KURL, 1985). Therefore, extension of the cytological knowledge on these tiny pest insects is highly warranted.

In the present communication, the diploid number, mitotic behaviour and morphometrical analysis of chromosomes in five species of aphids from the North-Eastern Himalayas are dealt with, of which ***Macrosiphum spirotibium***, ***Macrosiphoniella matsumurana*** and ***Aulacorthum magnoliae*** seem not to have been cytologically studied earlier.

MATERIALS AND METHODS

The somatic chromosome preparations were made from the young embryos of the apterous viviparous females of three species belonging to the sub-family Aphidinae and tribe Macrosiphini, namely, *Macrosiphum spirotibium* GHOSH & ROYCHAUDHURI, *Macrosiphoniella matsumurana* Ghosh, Basu & Raychaudhuri, and *Aulacorthum magnoliae* (Essing and Kuwana), one species of the tribe Aphidini, *Melanaphis bambusae* (Fullaway) and one species of the sub-family Lachninae and tribe Cinarini, *Cinara tujafilina* (del Guercio) by employing the sodium citrate-air drying-Giemsa stain schedule (KHUDA-BUKHSH & PAL, 1984a, 1985). The specimens were collected from the host plants *Artemesia vulgaris* (Compositae), *Artemesia vulgaris* (Compositae), *Sechium edule* (Cucurbitaceae), *Bambusa* sp. (Gramineae) and *Thuja* sp. (Cupressaceae) respectively in and around Kalimpong, District Darjeeling, West Bengal. Idiograms (Figs. 6—10) of the five species of aphids have been prepared on the relative percentage lengths (R_L) of individual pairs and the chromosome formula assigned according to KHUDA-BUKHSH & PAL (1984a, 1985).

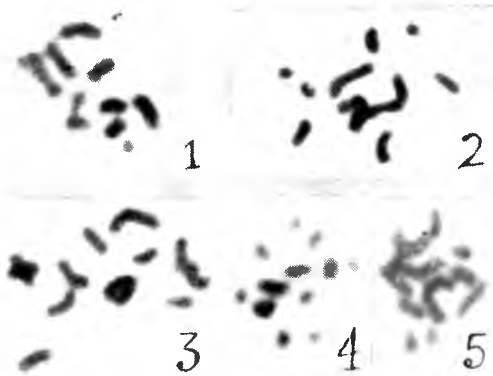
RESULTS

Mitotic behaviour of chromosomes: The mitotic behaviour of chromosomes was typically of the aphid pattern showing no structural differentiation, sheet-like movement of chromatin mass at anaphase etc.

Table 1. Mean lengths and relative percentage lengths (R_L) of chromosomes expressed as haploid set in five species of aphids from the North-Eastern Himalayas.

Name of species	Serial number of chromosomes (1) Mean l. (μm)	(1) R_L %	(2) Mean l. (μm)	(2) R_L %	(3) Mean l. (μm)	(3) R_L %	(4) Mean l. (μm)	(4) R_L %	(5) Mean l. (μm)	(5) R_L %	(6) Mean l. (μm)	(6) R_L %
Sub-fam : Aphidinae												
Tribe : Macrosiphini												
Macrosiphum spirotibium	3.77	24.95	2.94	19.45	2.52	16.67	2.28	15.08	1.90	12.57	1.70	11.20
SE	±0.34	M	0.44	S	0.39	S	0.41	S	0.36	S	0.24	S
Macrosiphoniella matsumurana	5.45	28.23	3.88	20.10	3.42	17.72	2.99	15.49	2.03	10.51	1.53	7.82
SE	±0.61	M	0.05	M	0.26	S	0.22	S	0.06	S	0.24	VS
Aulacorthum magnoliae	4.64	24.70	3.75	19.96	3.25	17.30	2.94	15.65	2.45	13.04	1.75	9.31
SE	±0.59	M	0.46	S	0.28	S	0.31	S	0.20	S	0.08	VS
Tribe : Aphidini												
Melanaphis bambusae	3.48	21.56	3.10	19.20	2.87	17.78	2.58	15.98	2.29	14.18	1.82	11.27
SE	±0.61	M	0.46	S	0.49	S	0.38	S	0.34	S	0.24	S
Sub-fam : Lachninae												
Tribe : Cinarini												
Cinara tujafilina	6.69	26.03	5.14	20.00	4.44	17.27	3.81	14.27	2.97	11.55	2.65	10.31
SE	±0.12	M	0.34	M	0.23	S	0.01	S	0.07	S	0.22	S

M = Medium (R_L 20%—30%); S = Short (R_L 10%—20%); VS = Very short (R_L Less than 10%).



(KHUDA BUKHSH & PAL, 1984b, 1985; DATTA & KHUDA BUKHSH, 1980).

Diploid number and morphometrical analysis: All the five species, viz., *Macrosiphum spirotibium* (Fig. 1), *Macrosiphoniella matsumurana* (Fig. 2), *Aulacorthum magnoliae* (Fig. 3), *Melanaphis bambusae* (Fig. 4), and *Cinara tujafilina* (Fig. 5) contained $2n = 12$ chromosomes at metaphase stage measuring between 3.77 and 1.70 μm, 5.45 and 1.53 μm, 4.64 and 1.75 μm, 3.48 and 1.82 μm and 6.69 and 2.65 μm, respectively (Table 1). The maximum difference in size between any two consecutive pairs was noted in all the five species between the 1st and 2nd pairs of chromosomes (Figs. 6–10), but it was more clear in *M. matsumurana* (1.57 μm; Fig. 7), *C. tujafilina* (1.55 μm; Fig. 10) and *M. spirotibium* (0.83 μm; Fig. 6) while it was less appreciable in *M. bambusae* (0.38 μm; Fig. 9). The minimum difference between two consecutive pairs was noted between the 5th and 6th pairs in *M. spirotibium* and *C. tujafilina*, between the 3rd and 4th pairs in *M. matsumurana* and *A. magnoliae*, and between the 2nd and 3rd pairs in *M. bambusae*. Depending on the R_L values of individual pairs of chromosomes, the chromosome formulae could be assigned as n = 1M (medium) + 5S (short) in *M. spirotibium* and *M. bambusae*, n=2M+3S+1VS (very short) in *M. matsumurana*, n = 1M + 4S + 1VS in *A. magnoliae* and n = 2M + 4S in *C. tujafilina*. Therefore although the diploid number was the same

in these five species, the detailed karyomorphometry differed to some extent from one species to the other.

DISCUSSION

So far as the authors are aware, the chromosomes of *Macrosiphum spirotibium*, *Macrosiphoniella matsumurana* and *Aulacorthum magnoliae* had not been studied earlier. Further, our findings of $2n=12$ chromosomes in *Melanaphis bambusae* are not in agreement with $2n = 10$ chromosomes reported earlier (KUZNETSOVA & SHAPOSHNIKOV, 1973). In the absence of detailed morphometrical data in the earlier study, it was not possible to compare the two karyotypes to make any suggestion for the difference. However, the occurrence of chromosomal polymorphism in this species might be thought of as has been found in case of some other species of aphids (BLACKMAN, 1980; KUZNETSOVA, 1968; KHUDA-BUKHSH & PAL, 1984b; PAL & KHUDA-BUKHSH, 1985a,b).

Our findings of $2n = 12$ in *Cinara tujafilina*, notwithstanding some difference in the morphometric data, agree well with that reported by DAS *et. al.* (1985). If the minor differences in the morphometrical data of individual pairs paticularly appreciable in case of 1st and 6th pairs, were not really due to technical shortcomings, then minor karyotypic differences could also occur between the two distant populations of this species. However, a further refinement of technique, such as G-banding, may prove helpful in analysing more critically such variations occurring in two natural populations.

Acknowledgements; The authors are indebted to Prof. G. K. MANNA for encouragement; to the Head, Department of Zoology, Kalyani University, for the laboratory facilities; to CSIR for the financial support of the work; to Dr. M. R. GHOSH, Head Department of Entomology, Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani and to Dr. D. RAYCHADHURI, Lecturer, Department of Zoology, Calcutta University for the identification of aphids and to Prof. A. K. SARKAR, Department of Botany, Kalyani University, for the identification of the plants.

REFERENCES

BLACKMAN, R. L. (1980) Chromosome numbers in the Aphididae and their taxonomic significance. *Systematic Ent.*, **5**, 7—25.

DAS, P. L., D. CHATTOPADHYAY & D. RAYCHAUDHURI (1985) Comparative karyological studies of two Cinarine aphids (Homoptera : Aphididae) from Kashmir valley. *Entomon*, **10**, 317—322.

DATTA, S. & A. R. KHUDA—BUKHSH (1980) Chromosomal study in the viviparous alatoid females of *Tinocallis kahawaluokalani* (Kirkaldy) (Homoptera: Aphididae). *Curr. Sci.*, **49**, 411—412.

KHUDA—BUKHSH, A. R. (1985) Trends in cytogenetical research of aphids in India. *Proc. 2nd National Symposium on "Recent Trends in Aphidological Studies"*, Modinagar, (In press).

KHUDA—BUKHSH, A. R. & N. B. PAL (1984a) Karyomorphology of five species of aphids. *Environ & Ecol.*, **2**, 329—332.

KHUDA—BUKHSH, A. R. & N. B. PAL (1984b) Further cytological investigations on *Lipaphis erysimi* (Homoptera: Aphididae): Chromosomal variations. *Proc. 4th All India Cong. Cytol & Genet., in: Perspectives in Cytology & Genetics*, (eds. MANNA, G. K. & SINHA, U.) **4**, 403—409.

KHUDA—BUKHSH, A. R. & N. B. PAL (1985) Cytogenetical studies on aphids (Homoptera; Aphididae) from India. I. Karyomorphology of eight species of *Aphis*. *Entomon* **10**, 171—177.

KURL, S. P. (1985) Cytogenetics of aphids (Homoptera: Aphidoidea). *Proc. 2nd National Symposium on "Recent Trends in Aphidological Studies"*. Modinagar, 13—28.

PAL, N. B. & A. R. KHUDA-BUKHSH (1965a) Karyological differences in two clones of an aphid *Brachycaudus helichrysi* collected from two host plants. *Environ. & Ecol.*, **3**, 485—488.

PAL, N. B. & A. R. KHUDA-BUKHSH (1985 b) Karyotypic variations in an unidentified species of aphid *Neonasonovia* collected from Garhwal Himalayas' *Environ. & Ecol.*, **3**, 548—550.

KUZNETSOVA, V. G. (1968) The karyotypes of the subfamily Anuraphidina. *Ent. Obozr.*, **47**, 767—781.

KUZNETSOVA, V, G. & G. H. SHAPOSHNIKOV (1973) Chromosome numbers of aphids (Homoptera : Aphidinea) of the world fauna (in Russian). *Ent. Obozr.*, **52**, 116—135.

Entomon, 1987, *Vol.* 12, *No.* 3, *pp.* 279 *to* 293

ORIENTAL CHALCID WASPS OF THE GENUS *TRIGONURA* SICHEL (HYMENOPTERA : CHALCIDIDAE)

T. C. Narendran

Department of Zoology, University of Calicut, Kerala, India 673 635

(Received 6 February 1986)

The species of *Trigonura* from Oriental Region are revised and a key given to 10 recognized species. Six new species viz , *T. steffani, T. indica, T. luzonensis, T. javensis, T. achterbergi* and *T. samarensis* are described. A checklist of world *Trigonura* species is also given

(*Key words:* oriental *Trigonura*, revision)

Sichel (1866) described *Trigonura* as a subgenus of *Phasganophora* Westwood and later Kirby (1883) gave it the generic status. Since then several authors like Kieffer (1911), Cameron (1913), Gahan and Fagan (1923), Girault (1924) and Nikol'skaya (1952) misidentified it and redescribed it under various names. Burks (1959) gave a good account of the North American species of *Trigonura*. Unfortunately no comprehensive treatment on the Oriental species of this genus has been published so far. In this paper I have attempted to give such a comprehensive account in a revisionary framework. At first I studied only the species of Indian subcontinent but it seemed necessary to expand the scope of this work to cover all the Oriental species since much larger material could be studied later during my study-stay at the U. S. National Meseum of Natural History, Washington, D. C. In addition to this, rich material was also received from Rijksmuseum van Natuurlijke Historie, Leiden.

The species of the genus *Trigonura* are probably distributed in all continents. They are, so far as is known, primary parasites of beetles developing in wood or under bark.

The abbreviations used in this paper are : BMNH : British Museum (Natural History), London; USNM : U. S. National Museum of Natural History, Washington, D. C.; RNH : Rijksmuseum van Natuurlijke Historie, Leiden and DZCU : Department of Zoology, University of Calicut.

Genus *Trigonura* Sichel

Phasganophora subg. *Trigonura* Sichel, 1866, Ann. Soc. Ent. France 4 (5) : 374, 358, 376.

Trigonura Sichel, Kirby, 1883, Jour. Linn. Soc. London, Zool. 17: 59; Dalla Torre, 1898, Cat. Hymenop. 5 : 372: Ashmead, 1904, Mem. Carnegie Mus. 1: 249, 250, 392; Schmiedeknecht, 1909, Gen. Ins. fasc. 97: 19, 22; Gahan and Fagan, 1923, Bull. U. S. Natl. Mus. 124: 149; Mani, 1938, Cat. Indian Ins.; pt. 23: 50: Steffan, 1950, Bull. Soc. Ent. France 55: 147; Burks, 1959, Ann. Ent. Am. 52 (1) : 75.

Type : *Phasganophora (Trigonura) crassicauda* Sichel; monotypic. *Bactrochalcis* Kieffer, 1912, Ann. Soc. Ent.

France 80: 463; Gahan and Fagan, 1923, Bull. U. S. Natl. Mus. 124: 21; Steffan, 1950, Bull. Soc. Ent. France 55: 147.

Type : *Bactrochalcis reticulata* Kieffer; monotypic. *Centrochalcis* Cameron, 1913 (not 1905), Indian Forest Rec. Ent. 9: 10; Gahan and Fagan, 1923, Bull. U. S. Natl. Mus. 124: 28; Mani, 1938, Cat. Indian Ins. pt. 23: 50; Steffan, 1950, Bull. Soc. Ent. France 55: 147.;

Type : *Centrochalcis ruficaudis* Cameron; monotypic. *Centrochalcidea* Gahan and Fagan, 1923, Bull. U. S. Natl. Mus. 124: 28; Steffan, 1950, Bull. Soc. Ent. France 55: 147 (New name for *Centrochalcis* Cameron 1913, not 1905).

Chalcidellia Girault, 1924, Homo perniciosus and new Hym. Priv. Printed, p. 3. Narendran, 1984, Entomophaga, 29 (4) : 432.

Type : *Chalcis euthyrrhini* Dodd, by original designation. *Urochalcis* Nikol'skaya, 1952, Opred Faune SSSR n. 44: 91, 92. Narendran, 1984, Entomophaga, 29 (4) : 432.

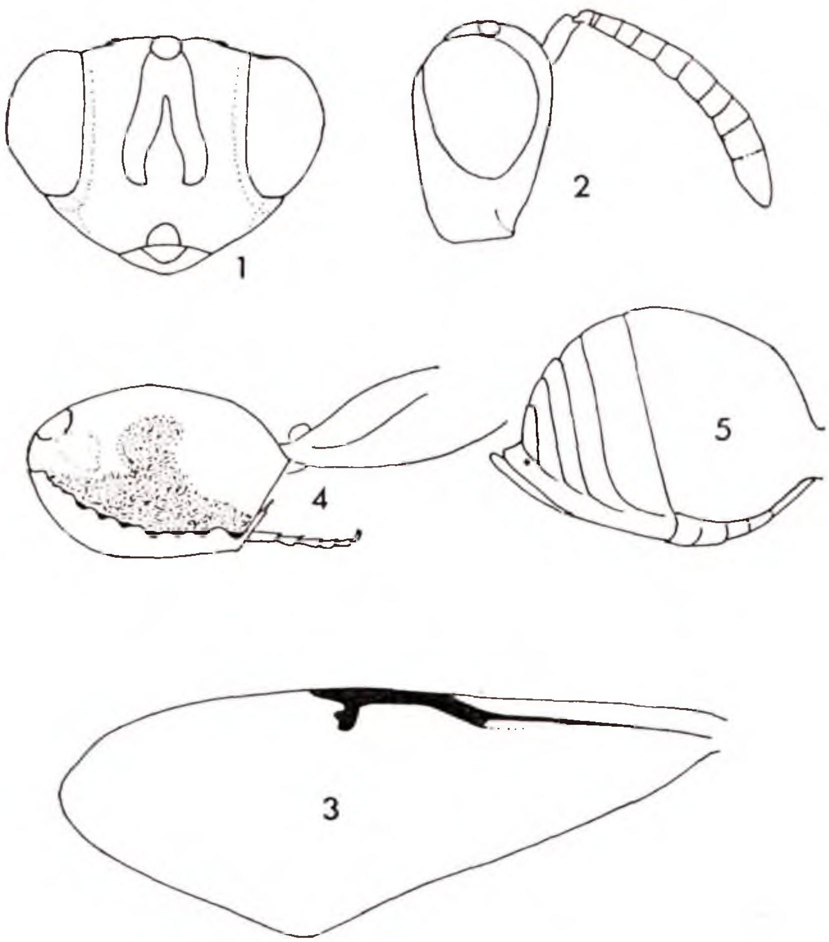
Type : *Urochalcis ninae* Nikol'skaya by original designation.

Among the Oriental genera of Chalcididae, the genus *Trigonura* comes very near the genus *Megalocolus* Kirby. However *Megalocolus* differs from *Trigonura* in having the antennal sockets fairly above the level of ventral margin of compound eyes, (much higher than that of *Trigonura*) in having usually five tergites of gaster visible before epipygium and in having apical area of scutellum with quadrate or subquadrate hollow depression (Narendran, 1984). Apart from the Oriental Chalcididae, the genus *Phasganophora* comes very close to *Trigonura* but *Phasganophora* Westwood differs from *Trigonura* in having characteristic raised rugae on the vertex, in having charactristic carinae on the first gasteral tergite and in having characteristic two elevations on the anterior margin of pronotum.

1. Trigonura steffani sp. nov. (Figs. 1–5, 16)

Female: Length 3.98 to 5.5 mm. Head and gaster black; antennal scape orange-red (in some cases scape blackish); eyes pale yellow; pronotum orange-brown with a black patch in the central middle region; mesoscutum with a black triangular patch in middle with other portions orange-brown (this black patch variable, sometimes extending more areas): scapulae black proximally and orange brown distally; axillae black (or black with orange-brown colour at their proximal sides narrowly); scutellum orange-brown with a narrow middle black portion which may be restricted to basal region in some specimens; wings slightly smoky; tegulae orange-brown. Fore legs and mid legs liver-brown with tips of their femora, bases and apices of their tibiae and tarsi pale yellow; hind coxae reddish-brown; hind femora with outer disc orange-red with black patch (Fig. 4) (in some cases this black patch extends to a larger area reducing the orange-red colour to a smaller portion) and a yellow spot at apex which extends to outer disc to another larger reddish-yellow patch; hind tibia brown with base black: tarsi dull yellow.

Head width subequal to the maximum width of thorax; closely punctate; punctures large and interstices rugose; moderately pubescent. Scobe deep, smooth and shiny, attaining front ocellus; eyes small but prominent, bulging and devoid of cilia. Interantennal projection broad with punctures. Relative measurements; Median ocellus 5; lateral ocellus 4.5;



Figs. 1—5. *Trigonura steffani* sp. nov. ♀. 1, head frontal aspect; 2, head and antenna in profile; 3, forewing; 4, hind leg; 5, gaster.

POL: 11; OOL: 3; the distance between median and lateral ocelli 3.1; interocular space at vertex 26. Antenna (Fig. 2) stout; scape reaches front ocellus; length of scape a little less than the combined length of funicular segments four to six. Mandible tridentate.

Thorax with pronotum transeverse, a little less than one-third as long as wide with large close umbilicate punctures; length of mesoscutum half its maximum width; notaulices complete; punctures on mesoscutum and scutellum large and close, interstices narrow and project as humps; scutellum narrow at base, broad posteriorly, with outer angles well rounded and depressed along middle towards posterior (apex not emarginate), posterior margin forming a narrow ridge with longitudinal costae; metanotum with fine longitudinal costae;

propodeum strongly declined posteriorly and angulate postero-lateraly; each side with a strong tooth near the spiracle. Forewing (Fig. 3) with M a little over one-third SM PM one-third M; stigmal shorter than PM. with 4 sensillae. Hind coxae with dense punctures and pubescence on ventral side without protuberance or tooth; hind femora (Fig. 4) on outer side densely punctate and sparsely pubescent, inner side without an inner basal tooth; outer ventral margin with a row of irregular teeth.

Gaster (Fig. 5) a little longer than thorax; first tergite smooth and shiny; second to fifth tergites on dorsal side smooth and shiny with punctures on posterior marginal side; sides of second to fifth tergites with more than a single row of setose punctures. Sixth tergite with three or four transverse rows of deep punctures; interspaces between the punctures smooth and shiny; epipygium somewhat compressed, carinate at middle; terebra short and very slightly projecting beyond the epipygium.

Male: Unknown

Holotypes : ♀ (No. Pl-3093) INDIA : KERALA, Calicut Uni. Campus; Narendran& Party; 19. ix. 1985; DZCU. **Paratypes** : 1 ♀, (PL-728) INDIA : KERALA, C. U. Campus, Narendran & Party, 18. iii. 1985; USNM; 1 ♀, (C. U. 3348) INDIA : TAMIL NADU, Nilgiris, date & collector unknown, BMNH.

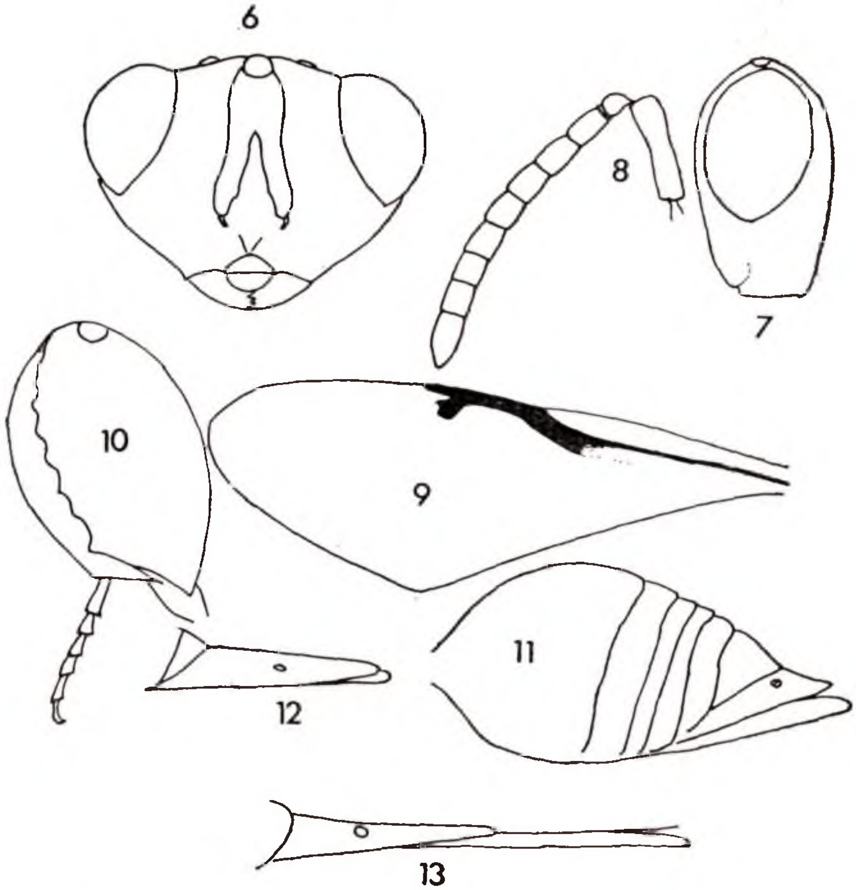
Remarks : This species has been named in honour of Dr. J. R. Steffan of Paris Museum for his significant contributions to the study of Chalcididae. This species comes close to *T. indica* sp. nov. and *T. luzonensis* sp. nov. but can be separated easily by the characters given in the key to species in this paper.

2. Trigonura indica sp. nov. (Figs. 6-11, 17)

Female : Length 5.17 to 7 mm. Head black; mandibles rusty-red except their tips where it is black; thoracic notum rusty red with black patch on scapula. Fore- and mid legs yellowish brown with bases and tips of femora and tibiae and all tarsi rusty red. Hind coxae and femora yellowish red with a yellow spot at apex; tegulae rusty-red.

Head width subequal to maximum width of thorax; closely punctate; punctures large and interstices rugose, moderately pubescent. Scrobe deep, smooth (except near front ocellus) and shiny, attaining front ocellus; interantennal projection broad with punctures; eyes small but prominent, bulging and devoid of cilia. Relative measurements : POL 10; OOL : 4, Median ocellus 6; Lateral ocellus 5; distance between median and lateral ocelli about one-third POL; interoculor space 28 at vertex. Antenna (Fig. 8) with scape reaching front ocellus; length of scape a little lesss than the combined length of segments four to six. Mandibles tridentate.

Thorax with pronotum transeverse, about one-third as long as wide, with large, close umbilicate punctures; length of mesoscutum a little over half its maximum width; nataulices complete; punctures on mesoscutum and scutellum large and close with interstices narrow and project as humps; scutellum narrow at base, broad posteriorly with outer angles somewhat rounded and depressed along middle towards posterior, apex not emarginate but forming a narrow ridge with longitudinal carinae. Propodeum strongly declined posteriorly and angulate posterio-laterally; each side with a small blunt tooth near spiracle. Forewing (Fig. 9) with M a trifle more



Figs. 6—13. *Trigonura indica* sp. nov. ♀ : 6, head frontal aspect; 7, head in profile; 8, antenna 9, forewing; 10, hind leg; 11, gaster; 12, *T. ruficaudis* : epipygium and ovipositor sheath; 13, *T. tenuicaudis* : epipygium and ovipositor sheath.

than one-third SM; PM a trifle more than one-fourth M; Stigmal a trifle shorter than PM. Hind coxae with dense punctures and moderate pubescence, without tooth or protuberance; hind femora on outer side closely punctate and moderately pubescent and inner side without a basal tooth, outer ventral margin with a row of irregular teeth.

Gaster (Fig. 11) distinctly longer than thorax; first tergite smooth, emarginate; second to fifth tegites on dorsal side smooth and shiny with a single row of setose punctures; sides of second to fifth tergites with more than a single row of punctures. Sixth tergite with three to five transeverse rows of shallow punctures. Epipygium compressed, carinate at middle; terebra short but distinctly projecting beyond epipygium.

Male : Unknown.

Holotype : 1 ♀ (PL–2289), INDIA : KARNATAKA, Bangalore, Narendran, 8. ix. 1981 DZCU. **Paratypes** : 1 ♀, (PL–2290), SINGAPORE, C. F. Baker, 1927, USNM,

Remarks : This species comes close to *T. steffani* sp. nov. but differs from it in having the epipygium length subeqal to the median length of sixth gasteral tergite and in having the first gasteral tergite emarginate posteriorly.

3. **Trigonura ruficaudis** (Cameron) (Fig. 12, 14, 15).

Centrochalcis ruficaudis Cameron, 1913, Indian For. Rec. 4:2, Dehra Dun (U. P.) (BMNH) (Examined).

This species is redescribed by Waterston (1922) and Mani and Dubey (1973). I examined the type of this species (Type No. 5-117, Female) at the BMNH and found the following important features: Face with dense pubescence and first gasteral tergite with sparse pits on dorsal side. However in specimens from Java the frontal pubescence is found to be less dense than that of the type and in other features these specimens agreed with the type. The male resembled the female in all fundamental features. Distribution : India, Bangla Desh, SriLanka, Pakistan and a new record for Java.

Hosts : *Chrysobothris* (Buprestidae), probably also *Glenea* sp., *Derolus discicollis* Gah. and *Diorthus simplex* White (Cerambycidae). I doubt the report of the host *Prosopis spicigera* (Prosopidae) (Mani and Dubey, 1973).

Material examined: **Holotype** (BMNH Type No. 5-117) ♀, INDIA: Dehra Dun, BMNH. Other material examined: 9 ♀♀ (Coll. Nos: PL-2610 to 2618), JAVA, L. G. E. Kalshoven. 3.ix, 1932 & v. 1932 1♂ of the same data, 11. ii. 1932 (Coll. No. PL-2619); USNM.

4. **Trigonura tenuicaudis** Waterston (Fig.13)

Trigonura tenuicaudis Waterston, 1922, Indian For. Rec. 9:12-14, Dehra Dun, BMNH, (Examined).

Waterston (1922) gave excellent description of this species. Mani and Dubey (1973) added a brief note to it. I examined the type (No. 5-III, ♀) at BMNH. The first gasteral tergite is smooth on dorsal side. Otherwise the description by Waterston is good enough to identify this species.

Distribution : India.

Hosts : Mainly *Chrysobothris* (Buprestidae) and probably also *Glenea* (Cerambycidae) and *Ozotomerus maculosus* Per. (Anthribidae).

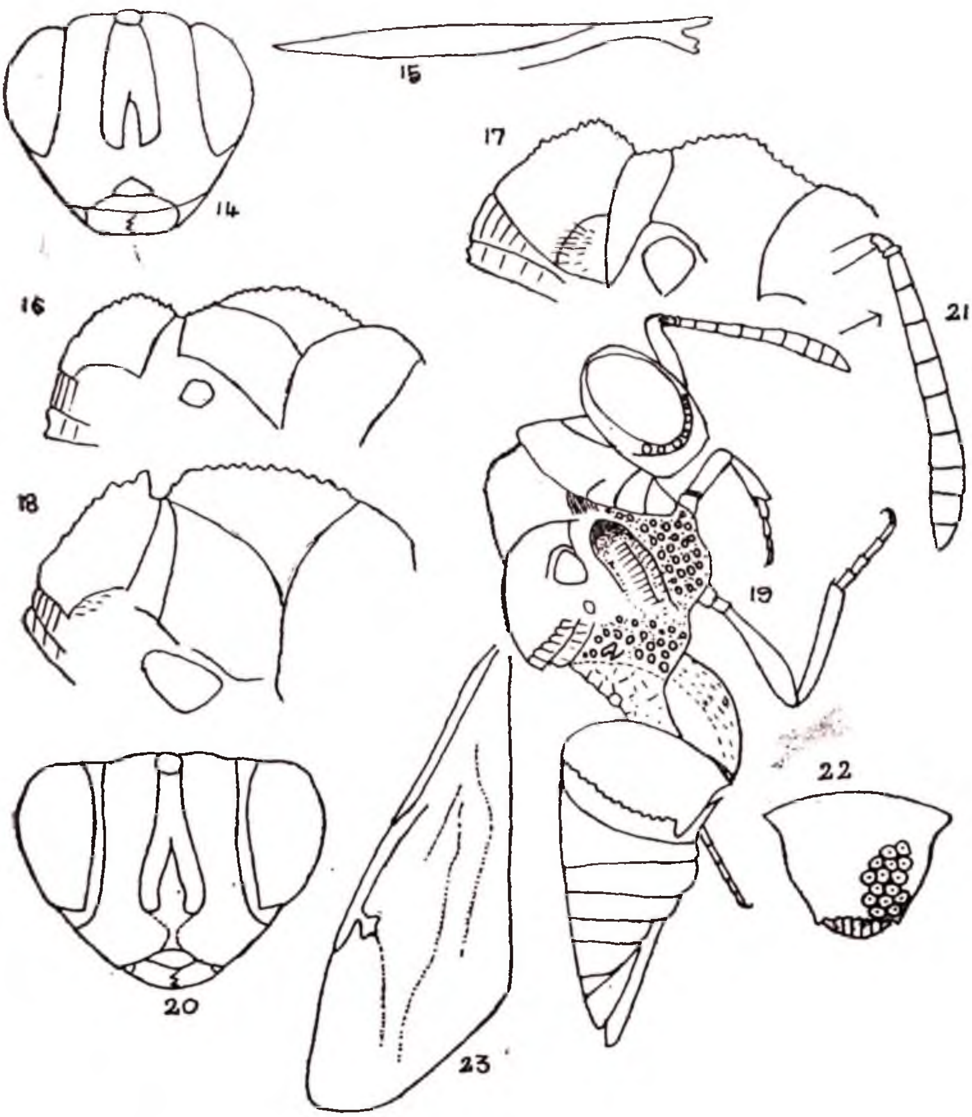
Material examined : **Holotype** ♀ (BMNH No. 5-III) only.

5. **Trigonura achterbergi** sp. nov. (Figs. 19-23)

Female: Length: 3.69-5.06 mm, Black tarsi, bases and apices of fore and mid tibiae brownish. Pubescence silvery, moderately dense on frons, ventral side of coxae and outer side of hind femora.

Head wider than pronotum : 55:45; frons not greatly convex, distinctly and deeply punctate; pre- and post- orbital carinae present; frontogenal suture absent; postgenal furrow not distinctly marked; interantennal projection broad and with characteristic microsculptures; POL 9; OOL 4; distance between Median and Lateral ocelli 3; Antennae swollen towards apex as in Fig. 21; scape reaches front ocellus.

Thorax with pronotum subequal to mesoscutum in width; deeply pitted, interstices carinate and raised as small humps in middle portions of pronotum and mesoscutum; mesoscutum convex towards anterior side as in Fig. 19; scutellum not convex; gently declined



Figs. 14—15. *Trigonura ruficaudis* ♀ : 14. head; 15, forewing veins; 16, *T. steffani* sp. nov. ♀ : lateral aspect of thoracic notum. 17, *T. indica* ♀: thoracic notum; 18, *T. luzonensis* sp. nov. ♀: thoracic notum in lateral view; Figs. 19—23 : *T. achterbergi* sp. nov. ♀ : 19, side view; 20, head; 21, antenna; 221 scutellum; 23, forewing.

posteriorly, posterior margin entire and somewhat semi-rectangular as in Fig. 22. Propodeum deeply pitted, prespiracular lateral tooth strongly developed; metanotum forming a round rim below apex of scutellum; petiole indistinct. Forewing (Fig. 23) with PM subeqal to stigmal, less than half M.

Hind coxa with moderately dense but relatively long pubescence on outer ventral side; hind femur with moderately dense pubescence which are relatively long, interstices smooth and shiny. Outer ventral margin of hind femur with a very characteristic large basal tooth as in Fig. 19, followed by a row of ten small irregular teeth; no inner basal tooth on hind femur present.

Gaster acuminate; first tergite smooth and shiny, less than half length of gaster; second to fifth tergites smooth and shiny on dorsal side with a single row of minute pits; sixth tergite with distinct and deep pits with interstices smooth and shiny.

Male : Length 3.69 mm. Similar to female; hind leg, distal half of antenna liver-brown and antennae not swollen as in female.

Holotype : 1 ♀ (PL-2605) INDONESIA : SULAWESI; C. V. Achterberg, 14. xi. 1985. **Paratypes** : 2 ♀ (PL-2606 & 2607) : coll. data same as that of Holotype, Holotype and the two paratypes in RNH. 1 ♀ (PL-2608) Philippines : Luzon, W. Robinson, Date of coll. unknown, USNM; 1 ♂ (PL-2609) : Philippines : Mindanoa; C. F. Baker, 1927, USNM.

Remarks : This species comes very close to *T. samarensis* sp. nov. in general features but can be separated from it in having the large characteristic tooth of hind femur, in having rectangular apex of scutellum and in having swollen distal portion of antennae of female. In *T. samarensis* frons is more convex and there is a large brown infuscation around the stigmal vein. This new species in named after Dr. C. V. Achterberg of RNH.

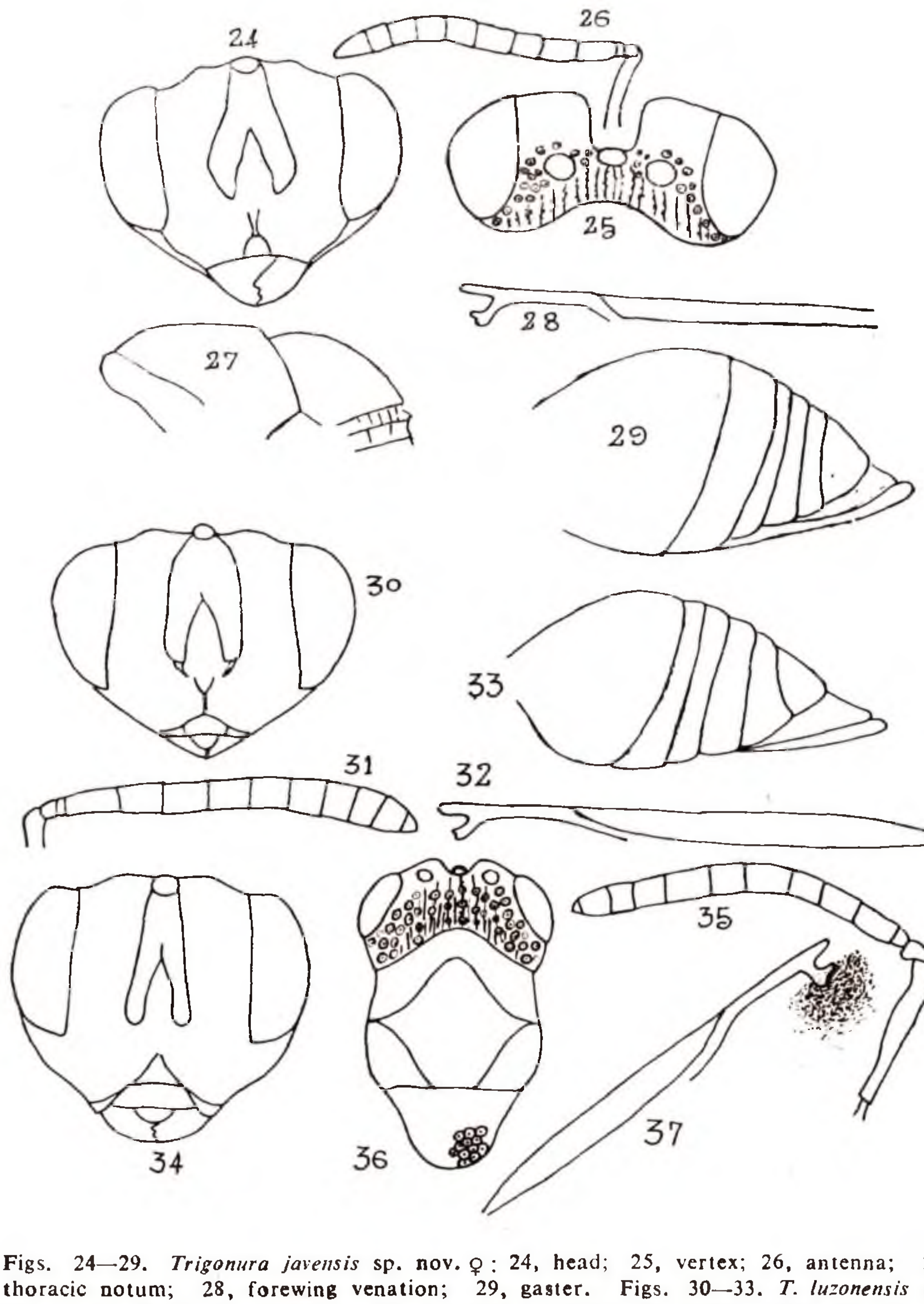
6. **Trigonura javensis** sp. nov. (Figs. 24–29)

Female : Length : 3.98–4.26 mm; Black with following parts otherwise : Eyes greyish; pronotum, mesoscutum, scapulae, scutellum and axillae ferrugenous red; sides of gasteral tergites brownish; hind coxa, femur and tibia liver-brownish black, tarsi pale brown; wings somewhat hyaline; mandibles and clypeus brownish red; metanotum, propleuron and mesopleuron partly rufous.

Head a little wider than the maximum width of thorax from dorsal side, densely pubescent; antennae inserted a little above level of ventral margin of compound eyes, interantennal projection a little wider than one antennal socket; lateral margin of scrobe angled laterally at ventral third; scrobe reaches front ocellus, inside smooth and shiny with faint shagreening; relative measurements POL 18; OOL 6; interocular distance at vertex 24; Antennal segments as in Fig. 26, scape reaches front ocellus. Mandibles tridentate. Vertex as in Fig. 25.

Thorax : pronotum with posterior margin deeply emarginate; mesoscutum not greatly convex as in *T. steffani*. Scutellum not vaulted (Fig. 27); pits on thoracic notum close and interstices narrow and hump-like; apex of scutellum rounded; forewing venation as in Fig. 28. Hind coxa without inner ventromesal or dorsal tooth; hind femur maty on outer side with a row of 10 or 11 teeth on ventral margin. Propodeum with a small lateral tooth near spiracle on each side.

Gaster (Fig. 29) a trifle shorter than thorax with basal tergite completely



Figs. 24—29. *Trigonura javensis* sp. nov. ♀ : 24, head; 25, vertex; 26, antenna; 27, thoracic notum; 28, forewing venation; 29, gaster. Figs. 30—33. *T. luzonensis* sp. nov. ♀ : 30, head; 31, antenna; 32, forewing venation; 33, gaster. Figs. 34—37. *T. samarensis* sp. nov. ♀ : 34, head; 35, antenna; 36, vertex and thoracic notum; 37, forewing venation.

smooth and shiny, posterior margin of basal tergite straight; tergites two to four asetose medially, setose laterally; fifth tergite with a basal row of setae, slightly emarginate posteriorly; sixth tergite with shallow pits, interstices shiny, inside pits rugulose. Epipygium carinate at middle.

Male : Unknown

Holotypes : ♀ (PL–2294) JAVA : Res. Semarang; Fr. A. TH. H. Verbeek, 8. vii. 1930; USNM. **Paratypes** : 3 ♀ (PL–2597 to 2599) same coll. data as for holotype, USNM.

Hosts : indetermined woodborers.

Remarks : This looks similar to *T. steffani* and *T. indica* in general appearance but differs clearly from them in not having vaulted scutellum and in several other miner features such as different proportion of antennal segments etc.

7. Trigonura luzonensis sp. nov. (Figs. 18, 30–33)

Female : Length 7 mm. Head black; mandibles rusty red except their tips which are black; thoracic notum rusty-red with pleurites and sternum black; legs black with the following parts rusty-red : tips of fore femora, tips of mid femora, bases and tips of fore tibiae, bases and tips of mid tibiae, hind coxae and all tarsi. Tegulae rusty-red; forewings slightly smoky.

Head width subequal to the maximum width of thorax; closely punctate; punctures large and interstices rugose; frons moderately pubescent: scrobe deep, smooth (except near front ocellus) and shiny, attaining front ocellus; interantennal projection as in Fig. 30; eyes small but prominent, devoid of cilia; median ocellus a trifle larger than lateral; distance between median and lateral ocelli about one-third POL; OOL 6.5; POL 16; interocular distance 39. Antenna inserted a little above the level of lower margin of eyes; scape reaching front ocellus; Mandbles tridentate.

Thorax with pronotum transeverse, about one-third as long as wide with large close umbilicate punctures; length of mesonotum a little over half its maximum width; nautalices complete; punctures on mesoscutum and scutellum large and close with interstices projecting as humps; scutellum narrow at base, broad posteriorly with outer angles somewhat rounded and depressed along the middle towards the posterior, apex not emarginate. Mesoscutum and scutellum convex and vaulted as in Fig. 18. Propodeum strongly declined posteriorly and angulate postero-laterally; sides with a small blunt tooth near spiracle. Forewing two and a half times as long as wide; venation as in Fig. 32. Hind coxa on ventral side densely punctate and moderately pubescent without protuberance or tooth; hind emora on outer disc closely punctate and moderately pubescent, innerside less pubescent and without an inner basal tooth, outer ventral margin with a row of irregular teeth.

Gaster (Fig. 33) distinctly longer than thorax; first tergite smooth and shiny; second to fifth tergites on dorsal side smooth and shiny with a single row of setose punctures; lateral sides of second to fifth tergites with more than a single row of punctures. Sixth tergite with fine transverse rows of shallow punctures; interstices and inside of pits rugose. Epipygium carinate at middle.

Male: 5.9 mm; similar to female except for stouter antenna and shorter gaster.

Holotype : ♀ (PL–2600) PHILIPPINES LUZON, Mt. Making, C. F. Boker, 1927; USNM.

Paratypes : 1♀ and 1♂ (PL–2601 & 2602) of the same data as for Holotype. 1 ♀ (C. U. 3349) on pin, INDIA: Nilgiris; Collector & data of collection unknown, BMNH.

Remarks : The species comes close to *T. indica* and at one time I thought it is the same as *T. indica*. However further studies on better materials revealed that both are different. The structure of the hind femur is quite different in both species. In *T. luzonensis* the outer disc is densely and minutely punctate and blackish, without any yellow spot whereas in *T. indica* the punctate are less closer on the hind femur and it is yellowish-red with a district characteristic yellow spot at apex. The dorsal side of pro and mesothorax in *T. luzonensis* is rusty-red without any black patches as in *T. indica*. The hind tibia is rufous with base black in *T. indica* whereas in *T. luzonensis* hind tibia is completely black. Nature of punctures on sixth gasteral tergite differs in both species.

8. Trigonura samarensis sp. nov. (Figs. 34—38)

Female : Length 5.77 mm. Black; eyes yellowish; tegulae, bases and apices of fore and mid femora, bases and apices of fore and mid tibiae, apices of hind tibiae brownish; all tarsi brownish. Wings hyaline with a black infuscation around stigmal.

Head wider than maximum width of thorax when measured from dorsal side; frons very convex when viewed from side, with deep, close pits. Scrobal margin as in Fig. 34, surface smooth and shiny except at apex where it is with parallel rugae; interantennal projection as in Fig. 34; antennae (Fig. 35) with scape reaching front ocellus, scape swollen at distal half; relative measurements: POL 24; OOL 8; Vertex and posterior part of head as in Fig. 36.

Thorax (Fig. 36) which close punctures and interstices narrow and hump-like; scutellum not vaulted or convex; mesoscutum slightly convex; apex of scutellum rounded,. Propodeum with strong tooth lateral to each spiracle. Forewing venation as in Fig. 37. Hind coxa without an inner ventromesal tooth or dorsal tooth; hind femur with outer ventral margin with a row of irregular teeth as in Fig. 38, without an inner basal tooth.

Gaster a little shorter than thorax, first tergite smooth and shiny, second tergite asetose medially, laterally with pubescence; tergite one to five not emarginate posteriorly. Sixth tergite with a few scattered shallow pits, inside pits and interstices shagreened and shiny; epipygium carinate medially.

Male : Length 3.9 mm Resembles the female in almost all features except for minor features like brownish-black gaster and more stoutish antenna etc.

Holotype : ♀ (PL–2603) PHILIPPINES : Samar island; C. F. Baker, 1927, USNM.

Paratype : 1 ♂ (PL–2604) INDIA : Nilgiris? ; collection date and collector unknown.

Remarks : This species resembles *T. achterbergi* and the two can be separated by the characters used in the key.

9. Trigonura gladiator (Walker) Comb. nov. (Figs. 39–45)

Halticella gladiator walker, 1862, Trans. ent. Soc. London I (3) : 360, Sarawak, BMNH. (Examined).

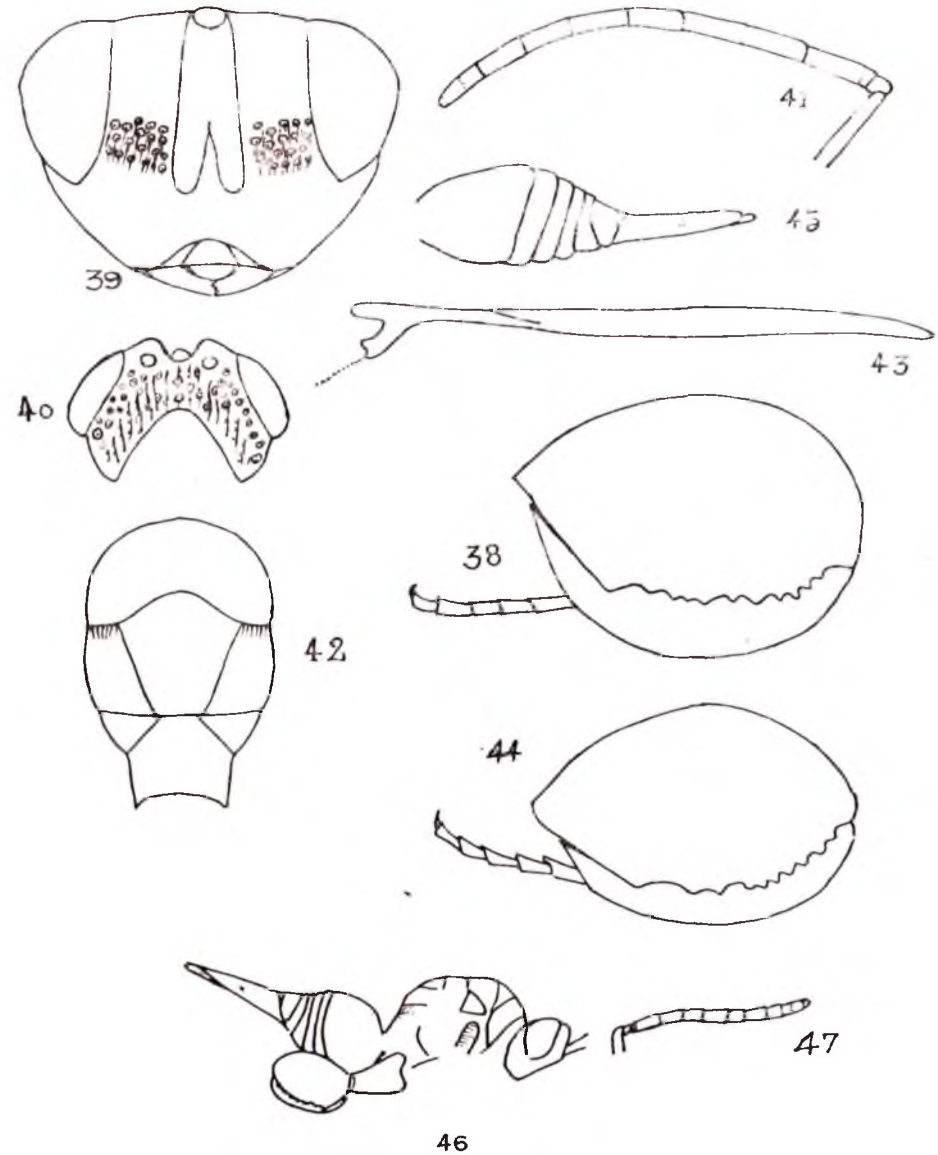


Fig. 38. *Trigonura samarensis* sp. nov. ♀ : hind leg. Figs. 39—45 : *T. gladiator* (Walker) ♀ : 39, head; 40, vertex; 41, antenna; 42, thoracic notum; 43, forewing venation; 44, hind femora; 45, gaster. Figs. 46—47. *T. backeri* Masi ♀ : 46, side view; 47, antennna.

Since the available description of this species is vague and insufficient for identifying this species, I redescribe this species below. The redescription is based on four specimens including the type.

Female : Length 8.52 –9.58 mm. Black with following parts otherwise : eyes and ocelli brownish yellow; first gasteral tergite reddish basally; second, third and fourth tergites liver-brownish; tegulae and all legs mostly liver-brown except tarsi which are brown. Wings moderately smoky; mandibles rufous except their black tips. Veins of forewings blackish.

Head (Fig. 39) a trifle wider than maximum width of thorax from dorsal side; frons with characteristic golden pubescence on parascrobal space medially (Fig. 39). POL and OOL as in Fig. 40; Mandibles bidentate. Antenna as in Fig. 41.

Thorax (Fig. 42) with characteristic dense pubescence on sides of posterior margin of pronotum; punctures on thorax close and interstices hump-like; mesoscutum and scutellum not vaulted as in *T. steffani* or *T. indica*; apex of scutellum characteristically semi-rectangular; propodeum with a small tooth near each spiracle. Hind coxa without a tooth on ventral or dorsal side; hind femur without an inner basal tooth, outer ventral margin with a row of irregular teeth, outer disc with distinct small pits and pubescence.

Gaster (Fig. 45) excluding epipygium and ovipositor shorter than thorax when measured from dorsal side; dorsal surface of first gasteral tergite smooth and shiny, median area glabrous, sides sparsely setose; second to fifth tergites each with a single row of brown setae; sixth tergite asetose with a few scattered deep pits, interstices broad and shiny, inside of pits smooth; epipygium smooth with sparse pubescence on sides.

Male: 5.54 mm. Similar to female but pubescence on frons and posterior sides of pronotum less dense than those of female.

Materials examined: **Holotype** ♀ (BMNH, Type No. 5–424), SARAWAK; Wallace. **Paratypes** : 2 ♀ and 1 ♂ (Coll, Nos. PL_2 291 to 2293) BORNEO : Sandak. C. F. Baker, 1927; USNM.

Remarks: This is a unique species with characteristic pubescence on frons and thorax and characteristic apex of scutellum. I examined the holotype at the British Museum (N. H.) and found it in not good condition. The head is found partly crushed on vertex.

10. Trigonura backeri Masi (Figs. 46–47)
Trigonura Bakeri Masi, 1926, Boll. Soc. Ent. Italiana 58 (2) : 21, PHILIPPINES: Basilan; USNM (Examined).

Since Masi's description is fairly good enough to recognize this species, I give below a few additional features which I noted during my study-stay at the USNM. Thoracic notum not vaulted as in *T. indica* or *T. luzonensis*; apex of scutellum rounded; first gasteral tergum with microsculptures; second to fifth emarginate posteriorly. The species can be separated from other Oriental species using the key given below.

Material examined : Holotype ♀ (USNM, Type No. 41768) PHILLIPPINES : Basilan; C. F. Baker, 1927; USNM.

KEY TO ORIENTAL SPECIES OF *TRIGONURA* SICHEL (CHALCIDOIDEA : CHALCIDIDAE)

1. Scutellum highly vaulted and convex (Figs. 16, 17, 18).. 2
— Scutellum not as above......................... 4

2. Gaster (Fig. 5) subglobose; length of epipygium subeqal to half the median length of sixth gasteral tergite; first gasteral tergite not emarginate at posterior margin, thoracic notum orange-brown with varying black patches..................T. steffani sp. nov.

— Gaster acuminate and oval (Figs. 11, 33); length of epipygium longer than above, subequal to median length of sixth gasteral tergite; other characters or combination of characters not as above.................. 3

3. First gasteral tergite well emarginate posteriorly; hind femur yellowish-red with a distict yellow spot at apex; hind tibia rusty-red with base black; thoracic notum rusty-red with black patches on scapulae ....*T. indica* sp. nov.

— First gasteral tergite slightly emarginate or not emarginate; hind tibia and femur completely black; thoracic notum rufous without any black patch.. *T. luzonensis* sp. nov.

4. Epipygium and ovipositor-sheath very long (Figs. 12, 13, 45, 46), both longer than first gasteral tergite....................................... 5

— Epipygium and ovipositor sheath short (Fig. 5, 11, 19, 29, 33,) 8

5. Frons with dense golden pubescence on middle region of parascrobal space (Fig. 39); posterior margin of pronotum with thick pubescence (Fig. 42) on sides; apex of scutellem semi-rectangular (Fig. 42)...... .... *T. gladiator* (Walker)

— Frons and pronotum not as above; scutellum not as above 6

6. Epipygium extends to near the tip of ovipositor sheath (Figs. 12, 46); first gasteral tergite with microsculptures................. 7

— Epipygium extends about half of ovipositor sheath (Fig. 13); first gasteral tergite smooth on dorsal side..*T. tenuicaudis* Waterston

7. Thoracic notum, sixth tergite and ovipositor sheath black; gasteral tergites second to fifth distinctly emarginate posteriorly.. .... *T. backeri* Masi

— Thoracic notum rufous with black patches; sixth tergite, epipygium and ovipositor sheath rufous.........*T. ruficaudis* (Cameron)

8. Predominently black all over head and body; propodeum with very strong and robust tooth lateral to each spiracle....... 9

— Pronotum, mesoscutum, part of metanotum and part of propodeum rufous, sides of gastral tergites brownish: hind coxa and tibia liver-brownish black; propodeal tooth near spiracle less robust and smaller ....*T. javensis* sp. nov.

9. The first tooth of ventral margin of hind femur predominently large (Fig. 19); antenna swollen towards distal half (Fig. 21); scape not swollen towards distal half; OOL less than one-third POL; frons not as convex as in the alternate couplet below.........................*T. achterbergi* sp. nov.

— First tooth of ventral margin of hind femur not predominently large as above; antenna (Fig. 35) not as above; scape swollen at distal half (Fig. 35); OOL one-third POL; frons very convex when viewed from side.....................*T. samarensis* sp. nov.

CHECKLIST OF *TRIGONURA* SICHEL OF THE WORLD

achterbergi Narendran sp. nov. Sarawak, Kalimantan (= Borneo).

algerti Burks, 1959, U. S. A.

annulipes Costa Lima, 1919, Brazil.

backeri Masi, 1926, Philippines.

californica Rohwer, 1917, U. S. A.

clavipes (Fabricius, 1804) *(Chalcis)*, S. America.

crassicauda (Sichel, 1866) *(Phasganophora)* West Indies.

dorsalis Ashmead, 1904, Brazil.

elegans (Provancher, 1887) *(Phasganophora)*, U. S. A. = *hicoriae* Rohwer, 1917.

euthyrrhini (Dood, 1921) *(Chalcis)*, Australia.

gladiator (Walker, 1862) *(Halticella)*, Sarawak.

guttatipennis (Girault, 1927) *(Chalcidellia)*, Australia

indica Narendran sp. nov. India

insularis (Cresson, 1865) *(Phasganophora)*, West Indies.

javensis Narendran sp. nov. Java.

luzonensis Narendran sp. nov. Philippines, India.

maura (Nikol'skaya, 1952) *(Urochalcis)*, USSR.

ninae (Nikol'skaya, 1952) *(Urochalcis)*, USSR.

oxyura (Hart.? year unknown), S. America.

pini Burks, 1959, U. S. A.

puertoricensis Wolcott, 1948, Puertorico.

reticulata (Kieffer, 1922) *(Bactrochalcis)*, Africa?

rubens (Klug, 1834) (Chalcis), Egypt, Israel.

ruficaudis (Cameron, 1913, not 1905) *(Centrochalcis)*, India, Java.

samarensis Narendian sp. nov. Philippines, India.

sphenopterae Nikol'skaya, 1960, USSR.

steffani Narendran sp. nov. India.

tarsata (Dalla Torre, 1894) *(Chalcis)*, U. S. A.

tenuicaudis Waterston, 1922, India.

ulmi Burks, 1959, U. S. A.

Acknowledgements. This research is financed in part by a grant made by the U S Department of Agriculture under Co-operative Agricultural Research Grant Programme (P L 480). I am greatly indebted to Dr. E. E. Grissell (U S National Museum, Washington, D. C.) for his help and suggestions, especially during my study-stay at washington, D. C.; Dr. J. R. Steffan (Maseum de Histoire Naturelle, Paris) helped me in identifying *T. steffani*. I am also very much indebted to Dr. C, V. Achterberg (Rijksmuseum van Natuurlike Histoire, Leiden) for a loan of several specimens of Chalcididae which contained some intersting material of *Trigonura* Sichel.

REFERENCES

Burks, B. D. (1959) The North American species of *Trigonura* (Hymenoptera : Chalcididae). *Ann. Ent. Soc. Am.*, **52**, 75—81.

Cameron, P. (1905) Description of some new species parasitic Hymenoptera chiefly from the Sikkim Himalaya. *Zeitschr. syst.* Hym. Dipt., **5**, 230.

Cameron, P. (1913) On the parasitic Hymenoptera reared at Dehra Dun, Northern India from the Lac (Tachardiae) and Gall Insects. *Indian For. Rec.*, **4**, 2.

Gahan, A. B. & M. M. Fagan (1923) The type species of the genera of Chalcidoidea or Chalcid flies. *Bull. Smith. Inst. U S Natl. Mus.*, **124**, 1—173.

Girault, A. A. (1924) Homo Perniciosus and and new Hymenoptera p. 3. *in*: The Privately Printed papers of A. A. Girault (compiled by G. Gordh, A. S. Menke, E. C. Dahms and Hall J. C. 1979). *Mem. Am. Ent. Inst.*, **28**, 124.

Kieffer, J. J. (1912) On *Bactrochalcis* (Hymenoptera). *Zeitschr. J. Hym. Dipt*,. **80**, 230.

Kirby, W. F. (1883) Remarks on the genera of the subfamily Chalcidinae, with synonymic notes and descriptions of new species of Leucospidinae and Chalcidinae. *J. Linn. Soc. (Zool).*, **17**, 53—58.

Mani, M. S. & O. P. Dubey (1973) Family Chalcididae : *in* Mani, M. S., Dubey, O. P. Kaul, B. K. and Saraswat, C. G. On some Chalcidoidea from India. *Mem. Sch. Ent.*, **2**, 1—128.

Masi, L. (1926) Descrizione di una nuova species di Trigonura (Hym. Chalcididae). *Est, Boll. Soc. ent. Ital.*, **58**, 21—24.

Narendran, T. C. (1984) Key to Indian Genera of the family Chalcididae (Hym. : Chalcidoidea). *Entomophaga*, **29** (4), 431—438.

Nikol'skaya, M. N. (1952) Khal'tsidy fauny SSSR, 73 datal' storo Akademie Nauk SSSR, Moskva-Leningrad, 1—566.

Sichel, J. (1865) Essai d' une Monographie des generes *Phasganophora* et *Conura, Ann. Soc. ent. France*, **5**(4), 376.

Stefean, J. R. (1950) Not sur la classification des Brachymeriinae (Hym. Chalcidiae). *Bull. Soc. ent. France.*, **10**, 146—149.

Walker, F. (1862) Notes on Chalicidites and characters of undescribed speeies. *Tras. ent. Soc. London.*, **1**(3), 358.

ANNOUNCEMENTS

10th INTERNATIONAL ZOOLOGY COLLOQUIUM

The 10th International Soil Zoology Colloquium is being held at Banglore, India, from August 7–13, 1988. The programme will cover all aspects of Soil Zoology with Soil Fauna and Management, Protection and Conservation as the main theme. For details, contact: Dr. D. Rajagopal, Secretary, 10th International Soil Zoology Colloquium, Department of Entomology, University of Agricultural Sciences, G. K. V. K. Campus, Bangalore 560 065, India.

JOURNAL OF APHIDOLOGY

The Aphidological Society announces publication of a biannual research journal, JOURNAL OF APHIDOLOGY. The journal will include original full length research papers and review articles on all aspects of aphid research. For details contact, Dr. S. P. Kurl, Secretary, The Aphidological Society, India, C/o Aphid Research Laboratory, Department of Zoology, M. M. Postgraduate College, Modinagar – 201 204, India.

Reg. No. R. N. 29386/76

ENTOMON is covered in the following abstracting/indexing journals : *Chemical Abstracts* (Chemical Abstracts Service, The Ohio State University, Columbus, Ohio 43210, U. S. A.), *Review of Applied Entomology* (Commonwealth Institute of Entomology, 56 Queen's Gate, London SW9 5JR, England), *Science Citation Index* and *Current Contents Agriculture, Biology & Environmental Sciences* (Institute of Scientific Information, 3501 Market Street, Philadelphia, Pa. 19103, U.S.A.), *Biological Abstracts* (Biosciences Information Service, 2100 Arch street Philadelphia, Pa. 19103, U. S. A.), *Entomology Abstracts* and other relevant *Abstracts* (Information Retrieval Limited, 1 Falconberg Court, Lodon WIV 5FG, England), *Referativny Zhurnal* (The Institute of Scientific Information, Academy of Science of the U. S. S. R., Baltijskaya ul., 14, Moscow A—219, U. S. S. R.), *Current Advance in Biological Sciences*, 132 New Walk, Leicester LEI 7QQ, England.

Published by V. K. K. Prabhu and Printed at GEO Printers, Plamood, Trivandrum 695 004
for the Association for Advancement of Entomology.